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EXAMINATION OF STREET LIGHTING PRACTICE IN GAINESVILLE

BY

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ACKNOWLEDGEMENTS

I would sincerely like to thank Electrical Engineering Technician Second(EET2) Class David Lea who works diligently with the Gainesville Regional Utility(GRU) designing lighting systems throughout the City. His patience through many meetings, among all others, insured the success of this report.

I also would like to thank Mr Bob Davis an energy analyst and representative to the Energy Advisory Committee(EAC) for his insight into lighting policy and cost data. I am also thankful for the time that officials of Florida Department of Transportation(FDOT) spent with me in both Lake City and Tallahassee. With their help, I was able to understand the state's involvement in City lighting projects as well as gain insight into their understanding of lighting design in municipalities under their jurisdiction.

Finally, I must say that although I learned an enormous amount of information about lighting design and policy in the past six months, essentially evolving from knowing nothing to a conversational knowledge of the topic, I truly believe the lighting engineering discipline can only be learned through hard work and years of practice. Therefore the following summary is my interpretation of the information I have gathered reflecting my limits of understanding and opinion with my personal recommendations to improve lighting policy and design in the City of

Gainesville.

This inquiry may seem to reflect on the heroic efforts made by individuals in the performance of their duties. However, I have nothing but the highest respect for their work. Throughout this discussion keep in mind that each raised issue is never a personal reflection on one's effectiveness or dedication to duty, but rather is often a result of a lack of appropriate policy formulation to meet rapidly changing needs causing the assumption of intolerable accountabilities.

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PREFACE

1.1 Background

City lighting for municipalities is an esoteric engineering discipline that is crucial to motorist and pedestrian comfort, security and safety. With the advent of the energy crisis in the seventies, city lighting has emerged nation-wide as a practical target for energy conservation effort, which unfortunately often lack definitive planning. In Gainesville, large differences exist between the needs demanded in areas with little or no lighting and areas that are over designed.[1] These extreme lighting variations coupled with a limited corporate knowledge of the basic principles of City lighting throughout the City and State is indicative of a policy and planning vacuum in dealing with City lighting policy.

1.2 Purpose

Primarily, this project was envisioned as an opportunity to improve knowledge of lighting, whether as street, security, or aesthetic, gained from experts in the City of Gainesville, throughout the State of Florida and through research. In the investigation of this topic, recommendations are offered that could be relevant in

[1] According to Mr Lea, GRU lighting, 25% of the City has no lighting, 40% needs improved lighting, and the remainder is over or properly lit.

achieving a better approach to street lighting for the City of Gainesville.

1.3 Objectives

In an effort to gain a better understanding of the issues, interviews were performed with those working in lighting. In the city, interviews and consultations were conducted with most relevant groups and individuals. Meetings were conducted with representatives of both the Lake City and Tallahassee Departments of Transportation. Finally a periodical search and a review of relevant and recommended documents obtained through discussions was conducted.

1.4 Recommendations

Finally, recommendations are offered covering areas including design standards, policy guidelines, equipment evaluation, rate structures, and personnel training. The following summary of recommendations is provided:

1. Currently no review of lighting requests is occurring. Most calls are forwarded by GRU lighting repair to GRU's Lighting Technician although some, more urgently, come from City officials through the chain of command. This factor is indicative of the lack of a coherent city-wide policy for lighting design. **I strongly recommend the convening of relevant officials within GRU and the City in drafting a comprehensive lighting policy, approved by the commission, that can be budgeted and executed.**

2. Currently one EET2 is accomplishing design and maintenance planning of all public lighting in the City, although this is a credit to the individual's diligent and productive efforts, other alternatives should be considered

based on engineering professional registration standards, noted omissions in current engineering design and the complexity of lighting design.

3. Undertakings by GRU lighting crews, since at least 1984, replacing higher wattage mercury vapor lighting with lower wattage high pressure sodium, as was recommended by the Roadway Lighting Conversion Report in 1981, should be continued with a goal of eliminating all mercury vapor lighting throughout the City at an appropriate schedule.

4. Have the City Auditor review and make recommendations in regards to billing procedures for #9940 Street Lighting Costs, of the non-departmental account within the General Fund, between the City Traffic Engineering Department and GRU.

5. Contract with ILLUME who drafted the 1981 Roadway Lighting Conversion Report to update their report as well as provide new recommendations to the City.

6. Although the EET2 in GRU went to the GE lighting school in 1985, efforts should be made available to encourage other manufacturer schools (Holofane, Sylvania etc) and coop programs with FDOT Tallahassee.

7. The City Hazardous Waste Coordinator should review current practices of disposing of high efficacy and heavy metal laden light luminaries.

8. Low Pressure Sodium(LPS) lighting considerations should be revisited by GRU, to tentatively determine if its use would warrant the cost savings and consistent lighting levels not attained by other sources.

9. Lighting Ballasts, which includes the wiring, capacitor, electronic spike unit and transformer that converts line to light voltage, have changed exceptionally in recent years. An investigation should be made to determine the most economical system for use in Gainesville.

10. A renewed study of the listing of recommended manufacturers by GRU of lighting equipment and materials should be considered.

11. Establish a review committee or board that meets periodically to assemble all players in the City's lighting policy.

12. The 1981 Roadway Lighting Conversion Report recommended a review of lighting rental rates that actually encouraged energy usage. A committee should be convened to review this

recommendation and ascertain if efforts should be made to provide disincentives to commercial lighting requests through higher rates or more energy conscious light selections.

13. As previously mentioned, a review of cost assumptions should be performed by GRU to validate lighting rate hypotheses.

14. Efforts to put all lighting information on an accessible database for the lighting technician on an interactive basis should be redoubled. No encompassing system exists, despite recommendations since 1981 by ILLUME, to analyze city-wide lighting data.

Ultimately, these recommendations emanate out of a lack of policy involvement by senior officials within GRU and the City Commission. Great credit should be given to those individuals in GRU who have forged ahead despite lack of managerial policy and commitment. However in hindsight, **these very efforts raise serious liability considerations that should have occasioned close consultations with the City Attorney.** In my opinion efforts in advancing a City Lighting Policy should be based on progressive and economical reforms. Interim efforts by Commission members, GRU and local citizens, such as the City Lighting Task Force, should be shelved in favor of a aggressive and comprehensive city-wide policy based on sound engineering judgement of managing lighting resources more efficiently.

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INTRODUCTION

Throughout the ages, man has overcome evening's darkness through lighting the night. Whether by campfire, gas, or electricity man has sought to increase his productive efforts through the safe extension of the day. Man has historically associated darkness with the unknown, mirroring his lack of visual perceptions, and has sought to prolong his days.

Today, man has change little. In Gainesville as recently as the 1970's, the Board of Realtors held a "Light the Night" campaign. In discussions throughout the City from those personally involved with lighting and those on the periphery, people in Gainesville feel lighting is not a privilege, but something that is expected. This includes not just residents but the police department, some commissioners and the local utility. More recently, attempts by the lighting branch of the local utility to convert residential lighting to lower costing, high pressure sodium lighting proved often sporadic since some complaining citizens didn't like the color. According to the Roadway Lighting Conversion Report of 1981, matters like these set the tone in the discussion of lighting management and execution with respect to the City of Gainesville.

In Gainesville, specific, city-wide lighting tasks are delegated to one electrical engineering technician who works

within the Gainesville Regional Utilities(GRU). He responds to all lighting issues whether a new request, an alteration, or a maintenance issue. On the other hand, all costs for lighting appear in the budget of the City's Director of Traffic Engineering who pays the monthly lighting costs as budgeted. Customer lighting costs are formulated every few years at GRU by there energy analysts and are based on light type and their associated costs. In the 1988 Energy Element, GRU energy analysts "implemented" IES lighting standards.[2] Unfortunately, GRU's design and maintenance practice reflect a myriad of design standards.

Both the regional and state portions of the Florida Department of Transportation (FDOT) carry lighting divisions who review only state funded projects. With the recent governor's directive to decentralize control, regional FDOT's now exercise absolute authority over their respective area wide lighting mandates while Tallahassee now acts as a quality assurance branch for the state's lighting policy. Within this framework of lighting enterprise, city-wide management currently does not have an endorsed lighting policy.

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[2] Ironically, the 1981 Roadway Lighting Conversion Report identifies IES standards as over designed and least energy conscious due to the high representation of lighting manufacturers on the IES steering committee. However, ultimately the Report felt, at that time, that IES standards could be adopted as a beginning framework, to be modified and adjusted to meet the City of Gainesville's needs.

CHAPTER FOUR
BACKGROUND

4.1 Lighting Types

City lighting, for the purposes of this report, is primarily of three types found almost exclusively on city streets and roadways: Mercury Vapor(MV), Metal Halide(MH) and High Pressure Sodium(HPS). Traditionally, the light of choice was MV. However with the arrival of higher efficacy(light/watt) lighting such as MH, HPS and to a lesser extent Low Pressure Sodium(LPS), lighting selection has made a quantum leap forward around the country and in Gainesville over the past ten years. Specifically, the new generation of lighting uses the same wattage to get increasing amounts of light as is seen in the Relative Efficacies of Light Sources. White light is a function of many electromagnetic frequencies that overlap and are largely unnecessary. Most higher efficacy lighting capitalizes on certain electromagnetic frequencies while

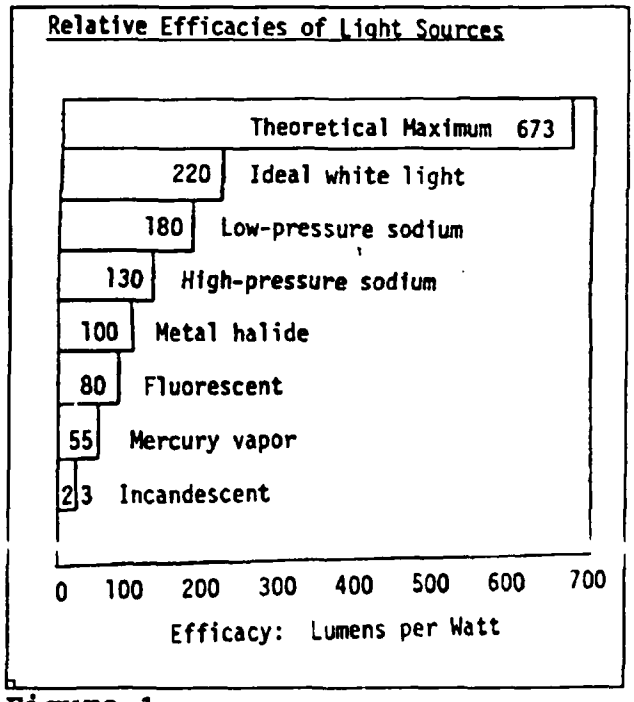

Figure 1

eliminating others with lower amounts of energy while maintaining light output, thereby producing colors that are not white but through study and engineering design produce the same safe required standards of traditional lighting. In Gainesville and elsewhere, Mercury Vapor lighting although scarce in large wattage sizes due to GRU efforts to curb energy use, remarkably can still be found in residential communities and other areas around the City.[3] Over the past ten years, most 1000 and 400 watt MV's have been switched to other higher efficacy type lighting. Although all new sub-divisions generally receive 150 or 250 Watt HPS and while MV fixtures are no longer available for rent or purchase through the GRU, 175 watt and some 1000 and 400 watt MV's are still widely found throughout the City.[4] In fact as far back as 1981, the Roadway Lighting and Conversion Report indicated approximately 92% of lighting in the City was MV.[5]

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[3] Efforts to identify exact locations of any light type or related information in the City is practically impossible due to the complete lack of progress in tracking lighting data in spite of recommendations of the 1981 Roadway Lighting Conversion Report. All aspirations of correcting this problem rest in the City's new GEOMAX system, where lighting information is currently being loaded.

[4] According to EET2 Lea at GRU, mercury vapor lighting currently constitutes "less than 50%, but more than 1/3 of all lighting in the City".

[5] From page 5 of the Roadway Lighting Conversion Report, of all existing MV light fixtures in the City in 1981: 3904 - 175 watt(66%), 1724 - 400 watt(29%), and 275 - 1000 watt(5%). There were a total of 6409 lights

According to those responsible in the utility, many citizens don't like the color(usually yellow) of HPS and prefer the white light of MV. Furthermore, efforts in the past to get the more effective, higher efficacy and cost effective lighting often resulted in rework when ordered through the chain of command to replace the existing MV lighting.[6] Metal Halide(MH) is white in color like MV lighting, but has higher efficacies. Since this lighting is generally not smaller than 250 watt and has higher life cycle costs than other alternatives, MH lighting is not prevalent in the City. However because of aesthetic benefits of white light, these light types(400 watt) can be found in the central city district.

High Pressure Sodium(HPS), recognized by its pinkish/amber color, has been a boon to municipalities throughout the country since its adoption in the late seventies and early eighties. The Roadway Lighting

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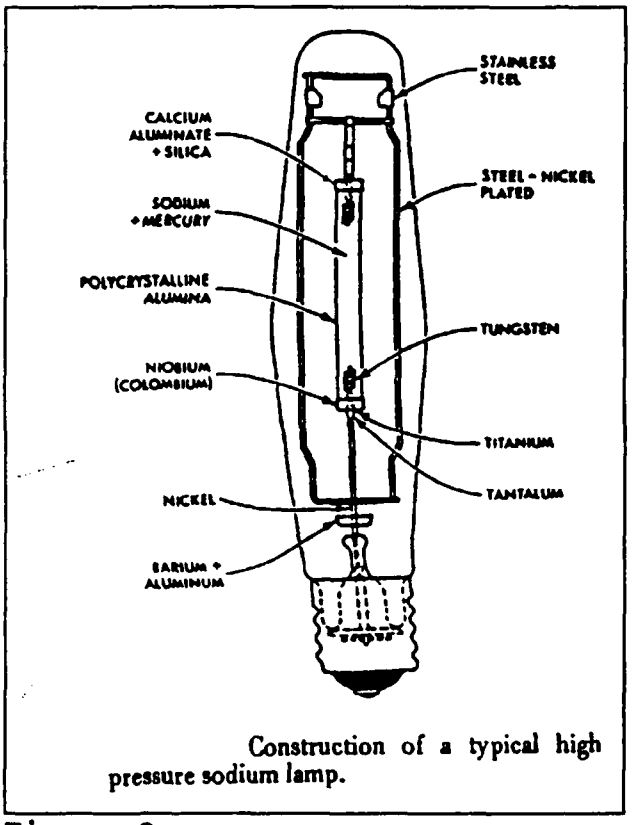
throughout the entire City with only 506 or 8% converted to HPS at the time of that report.

[6] The instance specifically mentioned occurred when a citizen complained that the new light(HPS), which was being installed when the other burned out, was not of the same color as the previous light(MV). The technician was later told by his boss to replace the existing bulb with an MV luminaire. Instead of waiting for a replacement, the urgency of the instructions required a cannibalization of an existing unit somewhere else in the City. In the final analysis, this not only included the rework of putting the old light back, but also included the work necessary to replace the cannibalized light. Nonetheless, this set the tone of our conversation and his efforts in administering a city wide conversion program.



Construction of a typical high pressure sodium lamp.

Figure 2

Conversion Report recommended an adoption of this standard in its 1981 summary because of HPS lighting's superior efficacies. Efforts have been made to eliminate all large MV lighting for the last several years with an HPS substitute of an approximate lumen basis. This has in all likelihood, in the absence of a mandated and documented program, been effective in lowering energy costs and has proven easy to adopt through the replacement of normal light failures. However these practices raise some serious questions. As will be discussed, poles are almost never being relocated to accommodate the new design standards and there doesn't seem

to be a program of proposed pole relocation.[7] Currently those responsible for the conversion rely solely on General Electric conversion data.[8]

Finally, Low Pressure Sodium Lighting(amber light) has the highest efficacy of any fixture. Also unlike other high efficacy lighting which degrade in light output over time, LPS has a constant light output through time which is important in insuring lighting design continually complies with accepted design practices. However since the light is monochromatic, other colors cannot be distinguished within its amber proximity which seems, as previously discussed, to be important in any discussion of lighting in the City of

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[7] According to Mr Lester Jones of FDOT Tallahassee, lighting conversion of existing MV systems should include pole relocation considerations since fringibility standards of the existing pole do not meet current requirements. Fringibility addresses the distance at which the pole is off-set from the arterial. This is relevant to pedestrian safety in the occurrence of errant vehicle collisions with poles on sidewalks. Not establishing a program of pole relocation to recognize fringibility could raise liability questions.

[8] Use of these tables are not improper in themselves, but one should recognize that conversion of MV to HPS, according to GE conversion tables, is based on equivalency of light output only. For example, a 400 Watt MV is converted to a 250 Watt HPS. Other issues of pole relocation and complete conformance to established standards should be insured. According to Mr Lester Jones of FDOT Tallahassee, the first step in the state lighting conversion program was the creation of a "matter of record" in establishing state lighting policy. Furthermore, he felt this was essential to protect those executing the conversion to HPS of a state MV dominated system that was already inadequately lit and, although cheaper to operate, would still be inadequately lit. According to Mr Lester Jones, the City should establish a lighting policy first.

Gainesville. Another problem often mentioned but not verified by supporting data, involves the chemical instability of sodium, ironically only within the LPS(not HPS) fixture, when it comes in contact with water which may imply disposal problems.[9] Here arises some of the conjecture as to its slow acceptance around the country. GRU has decided, although to my knowledge not in writing, to not use LPS on any City projects despite its proven cost savings.

4.2 1981 Roadway Lighting Conversion Report

In October of 1981 ILLUME, a lighting consultant based out of Portland, Oregon, released its Roadway Lighting Conversion Report based at the time on a study of Gainesville's current lighting practices. The report according to officials in GRU was adopted by the City Commission.[10] The report was primarily an attempt to insure the City, through GRU, would stay abreast with proper

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[9] Although hazardous wastes are evident in all high efficacy light fixtures produced, City fixtures are not being disposed in any unique manner. It is assumed at GRU that the low specific quantities pose no threat to normal disposal.

[10] In reviewing records in the Clerks Office with Ms Judy Fraser. No copy or record of the 1981 Roadway Lighting Conversion Report could be found. Commission minutes were reviewed during that time with no mention of the Report. Copies of the Report, although scarce, can still be found with Mr Bob Davis - Energy Analyst, GRU or Mr David Lea - EET2, GRU.

conversion of lighting to high efficacy systems. The Report in most part, after the adoption of a city-wide lighting plan, proposed a systematic approach to converting MV lighting to HPS & MH.[11] This included lighting manufacturer information and analysis covering ballasts, luminaires and lamps as well as non-computer procedures to monitor and properly maintain the utility's lighting system. However the report conclusively stated that the advancing of any recommendations was contingent on development of standards for Gainesville. Intuitively, this meant adoption of lighting policy guidelines by City and GRU officials. According to the Report in 1981, "There are no existing street classifications used in Gainesville for lighting or

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[11] Despite the Report, progress has been extremely slow in adopting a system of lighting design and monitoring. Current practices in lighting conversion mirror practices the Report cited as fallacious in 1981: "Typically, municipalities are satisfied to convert on an approximate lumen basis, that is, to replace an existing mercury vapor(mv) lamp with a high pressure sodium(hps) lamp that has similar initial light output but of lower wattage(less energy consumption). There are two fallacies in this approach:

1. It assumes all streets are currently lighted to optimum conditions. Since energy and products were cheap and abundant at the time these systems were designed this is highly unlikely and in fact, a rare occurrence.

2. This method relies on design technology of 20 years ago. Design parameters, equipment, and economies have varied greatly since then."

Gainesville currently uses manufacturer conversion tables(GE) in converting MV to HPS, based solely on approximate lumen basis, without consideration of degradation of standards due to other design parameters. This may be acceptable if this form of conversion was sufficiently reviewed for safety and was formally adopted by the City to avoid litigation challenges.

planning purposes and the IES classifications can be used" as a basic framework in establishing City standards.[12]

4.3 Street Light Design

Street Lighting Design, whether on new FDOT funded or City roads, is completed by the GRU design branch. Currently the light of choice in Gainesville and around the state is HPS. The HPS light type is determined by design through a series of isofootcandle templates, as can be seen in figure 3, or computer programs purchased from the manufacturer. These methods are primarily based on both the light wattage, fixture type and pole height being used. The size is limited to what can be purchased and is usually a 100, 150, 250, or 400 HPS watt light. All else equal, the larger the light the larger the luminous envelope below the light.

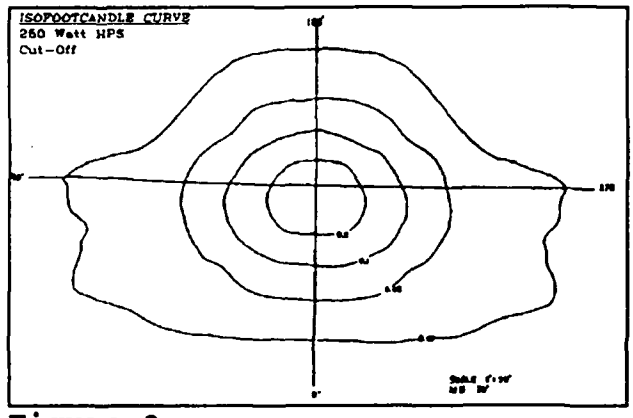

Figure 3

Next there are two main types of light fixtures available for street use: Cobra Head and Cut-Off. The cobra head is distinguished by the fire ball that extends

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[12] p. 41, 1981 Roadway Lighting Conversion Report

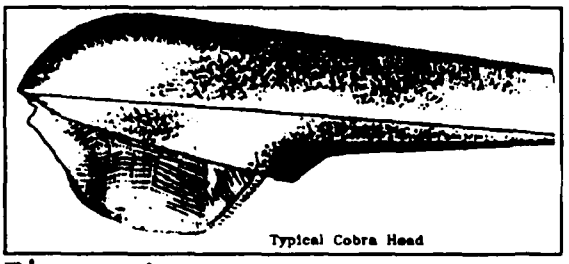

Figure 4

below the light housing. The cobra head by geometry emits a large elliptical envelope of light with the light source near one end of the ellipse. In an effort to alter the light envelope and decrease "light trespassing" on adjacent property owners as well as blinding motorists, the Cut-Off light was advanced. The Cut-Off light is available in varying sizes as determined by the included angle at which the light strikes the surface below and is noted by a flat clear plate on the bottom of the fixture. The most common fixture is the 78 degree type. This maximizes on the elliptical pattern as well as preventing blindness to motorists as can be seen in the following figure. Although slightly more expensive, Gainesville is currently projecting a complete conversion to the more progressive cut-off fixtures for all City

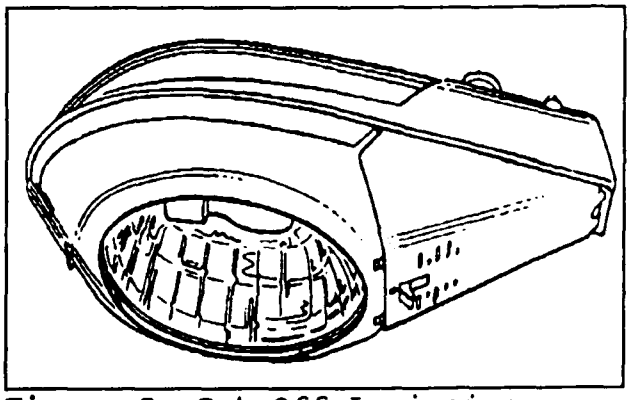

Figure 5 Cut-Off Luminaire

lighting.[13] Finally, the pole height relates to the size of the luminous envelope and the intensity of the light hitting the road surface. The higher the pole, the larger the envelope and the lower the intensity on the surface of the road. Generally on most roads in the City, 150 or 250 watt HPS lights with Cut-Off fixtures are found at varying pole heights. In laying the templates to insure proper roadway coverage of illumination, certain criteria must be referred to insure conformance to accepted design standards. Although in the 1988 Energy Element #114, IES/ANSE lighting standards are "implemented" by the energy analysts at GRU, continued and current practice throughout the City reflects a myriad of standards including IES/ANSE, FDOT(1978), and

[13] According to EET2 Lea at GRU, currently 8934(63%) fixtures are Cut-Off out of a utility population of 14,256 fixtures. The 1981 Roadway Lighting Conversion Report recommended this progressive adoption. Unfortunately in recent weeks, to quell commission interest in specific community lighting, efforts will be made to adopt a 1/2 cut-off luminaire in areas where residents want more "light". This will be accomplished by replacing existing full cut-off luminaires only. Although this practice gives the perception of more light, in fact only more glare, light trespass and "sky glow" will be realized.

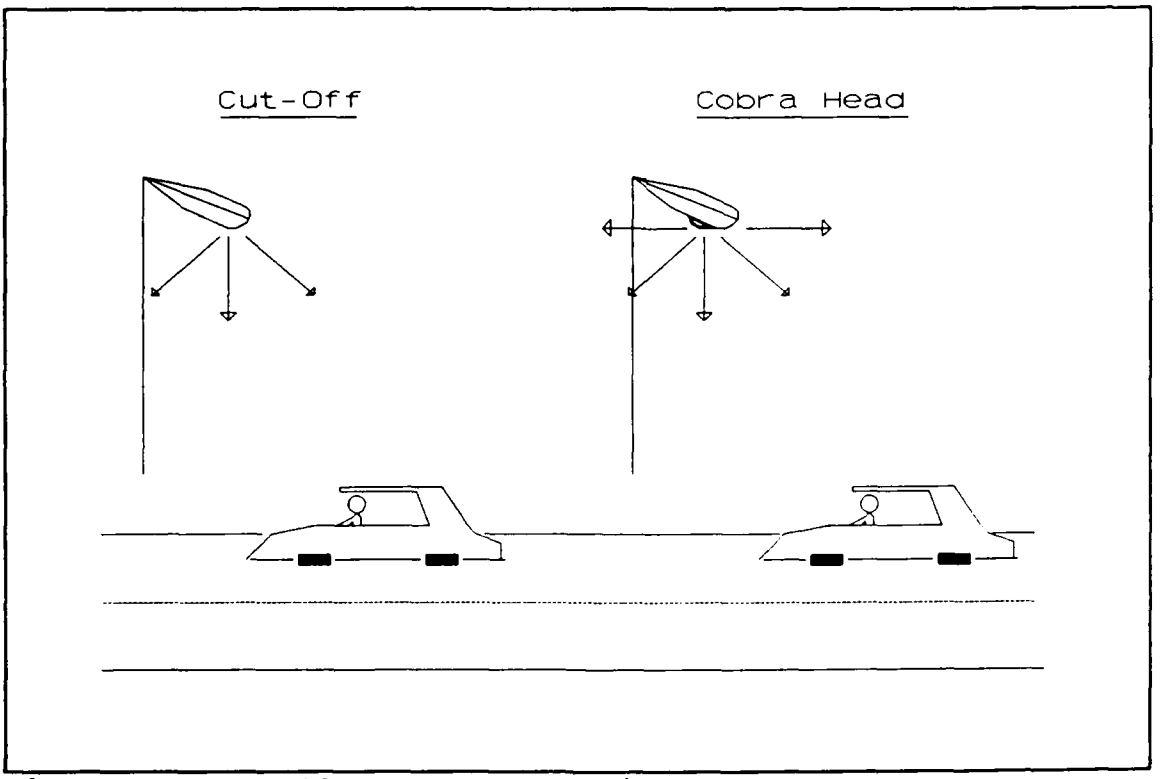

Figure 6 Cut-Off & Cobra Head Light Geometry

AASHTO.[14] Of interesting note was the commonly used FDOT standard from 1978 which was revised in 1984. The newer

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[14] Although the 1981 Roadway Lighting Conversion Report recommended IES standards, FDOT currently fails to recommend these standards in it's Highway Lighting Guidelines. See Appendix A-1. According to Mr Lester Jones of FDOT, IES standards do not contain rigorous energy conservation considerations in their lighting recommendations. He made the comparison between a cadillac and other cars in saying they both get the job done with one doing it more economically than the other.

However the mere adoption of any standard is better than the current hodgepodge of lighting standards that is currently endorsed. According to Mr Beaulieu, the recently appointed Electrical Engineering Manager, IES Standards will soon be recommended for adoption by GRU.

standards reflected less energy consuming criteria.[15] Unfortunately, with no city-wide policy, each standard seems to be used in varying circumstances at the discretion of the lighting branch of GRU. Regardless, these guidelines deal with the light source type, the illumination levels impacting the surfaces of various conditions(ie: ramps, crossroads etc), uniformity of light from the brightest to the lowest, and the pole height & setback.[16] Each standard prescribes, in a cookbook fashion, the optimum lighting conditions for the roadway surface. Significantly, these guidelines do not address policy guidelines of what should and shouldn't be lit. In fact based on the guidelines alone, **they each intrinsically call for complete**

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[15] Any FDOT project and others in the City that were designed by GRU based on 1978 FDOT guidelines since 1984, including 39th Ave, were based on old standards. Specifically, illumination levels on urban arterials decrease by 25% from 2.0 to 1.5 average initial horizontal foot candles and uniformity decreased from a strict 3 to 4:1 to less than 4:1, see Appendix A-1. These figures amount to significant savings attributable to no specific design policy guidelines being dictated by the City. Of interesting note to Professor Collier was the adoption in the 1984 FDOT standard of 175 watt MV luminaries for sign lighting as opposed to the older 250 watt design as recommended by his report for FDOT titled, Development of Standards for Illuminated Signs - Phase 1.

[16] Uniformity is especially important in regards to a decision by the City in the seventies, during the energy crisis, when it was decided to reduce energy costs by shutting off every other light. Uniformity of lighting between lamps should remain below 4:1 from lightest to darkest points. If this is exceeded as in the case of shutting off alternate lights, the "flicker effect" seriously impairs motorist judgement and orientation due to the eye's inability to compensate for the intensity changes.

illumination of all road surfaces within GRU's jurisdiction!

4.4 Lighting Costs

Lighting costs are charged all customers equally whether FDOT, commercial or the City. However FDOT pays for all costs in a lump sum reimbursable arrangement and all others pay over an amortized basis. Charges are based on pole, light type and maintenance related assessments as can be seen in Appendix A-2.

When street lighting is designed for the FDOT within the City, actual costs of pole and installation charges(Appendix A-3) are directly billed. Additionally, GRU insures annual clean and relamp costs(Appendix A-4) and bills the City Traffic Engineer for future recurring charges.

Both Commercial and City lighting charges reflect a monthly amortized life cycle rate. An exception occurs if GRU designs and installs lighting for commercial use(ie: parking, security etc) where a five year contract is required with early removal penalties so as to insure the utility recovers its installation and design costs resulting from unfulfilled amortized charges.[17] As can be seen, amortized lighting rates are based on the type of light,

[17] Commercial lighting accounts for slightly less than a third of all lighting provided by the utility to it's operating area.

installation, and operations and maintenance costs (Appendix A-5).

GRU has made efforts to adopt recommendations made by the 1981 Roadway Lighting Conversion Report by making unavailable to the public, lighting systems that are inefficient or encourage light trespass. Although preventing public rental of Cobra Head fixtures is helpful in controlling light trespass, current public rental of other lighting might still be debated.[18] Another issue might be GRU's current practice of amortizing concrete and wood poles over the same life cycle of 15 years.[19] Although wood poles may last 15 years, comparing them equally removes the life cycle benefits of concrete poles since their

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[18] The Roadway Lighting Conversion Report recommended the elimination of commercial available lighting with reasonable rates and unattractive design. Although reasonable rental rates encourage wide utilization throughout the City, a GRU interest, this is often accompanied, according to the report, with "utilitarian rentals on crooked wood power poles" instead of permanent, attractive lights. Additionally during that period many inefficient flood lights were offered. Although decorative rentals are now offered, the rate structure does not seem altered to reflect a disincentive to rental usage over permanently installed lights.

[19] FDOT normally uses safer and longer life cycle "Break away" aluminum poles on all state funded projects. Only at city and municipality request are concrete poles, alone, granted. The State's interest is in the safest and most economical pole which in this case requires a higher first cost. However GRU's position seems to be to recover capital outlays in the shortest possible time which requires unique pole life cycles with lower first costs associated with pole selection. Therefore GRU uses mostly wood poles with lower first costs and the State uses mostly aluminum poles with lower life cycle costs.

initial costs exceed wood poles. When inquiring about this discrepancy and counter to life cycle theory, I was told that even though the public is charged amortized costs GRU still has to outlay the first costs and can get more wood than concrete poles. Another explanation offered by the energy analysts was that no one really knows the life of concrete poles and for all intent and purposes assumes a useable life of 15 years. Finally as can be seen from Appendix A-2 under "% Difference To Cost of Service" according to Mr Bob Davis, GRU, the public rate is almost always lagging the total cost of service in most light types since a rate adjustment has not been done for these areas since 1984. This may be interpreted as a future request to a rate hike.

4.5 Light Funding & Oversight

As was discussed in laying out templates in street light design, an approximate number of lights is determined. If the design is for an FDOT project within the City, the design and gross costs are forwarded to FDOT Lake City for approval and inclusion into funding of the FDOT roadway(ie:

39th Ave).[20] If the design is implemented by the City whether public or commercial, life cycle amortized and first cost charges are billed the user, see Appendix A-2.

4.5.1 Light Funding & Oversight - City

In discussions with the City's Traffic Engineer, no review of requested lighting is being conducted by non-departmental fund managers within the department, with the exception of insuring it doesn't break the budget. There is no understanding of warranting procedures for allocating limited resources to City lighting needs through a warranting process(See Appendix A-6) of either the Department of Transportation sanctioned Roadway Lighting Handbook warranting process or a hybrid type for the City. Furthermore, the traffic engineer thought all lighting planning for the City was being handled by GRU and he just increased his lighting costs from budget year to year to account for anticipated outlays for lighting(See Figure

[20] According to GRU, the City is not in the habit of designing lighting systems for FDOT roadways, however in the case of 39th Ave the Mayor and City Manager realized additional funds were available to increase the scope of work as was designed by the A/E to include street lighting. FDOT agreed to review the proposal if the City submitted the design and required documentation.

7).[21] Three years ago, the traffic engineer reviewed all specific lighting requests, but found that almost all were approved, requiring no real oversight. Since oversight was being duplicated by GRU after being approved by the Traffic Engineering Department, the Director relinquished authority to control City lighting to GRU.[22] From observation, the traffic engineer has no one on staff who has the background to review the technical sufficiency or wisdom of each lighting request made by the City or from within it's constituency. Monthly, GRU sends a lighting summary to the department. A source requesting anonymity, closely aware of the City Lighting Costs, expressed confusion with being responsible for a budgeted item with no oversight or expertise in this area. Furthermore according to the source, they don't understand what it says and keep no records of monthly listings.

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[21] Street Lighting Costs(9940), a non-departmental account within the General Fund(001), were easily tracked back through FY 80. Prior to 1980, Street Lighting Costs were incorporated into other budgetary organizations and could not be reliably extracted.

[22] In discussions with Mr Cameron and Mr Beaulieu at GRU, upcoming discussions of Lighting issues sanctioned by the new City Manager will entail the liberation of GRU of the responsibility of managing City lighting directions and standards. Instead, GRU feels that it should only design and deliver the required product and not manage it's allocation.

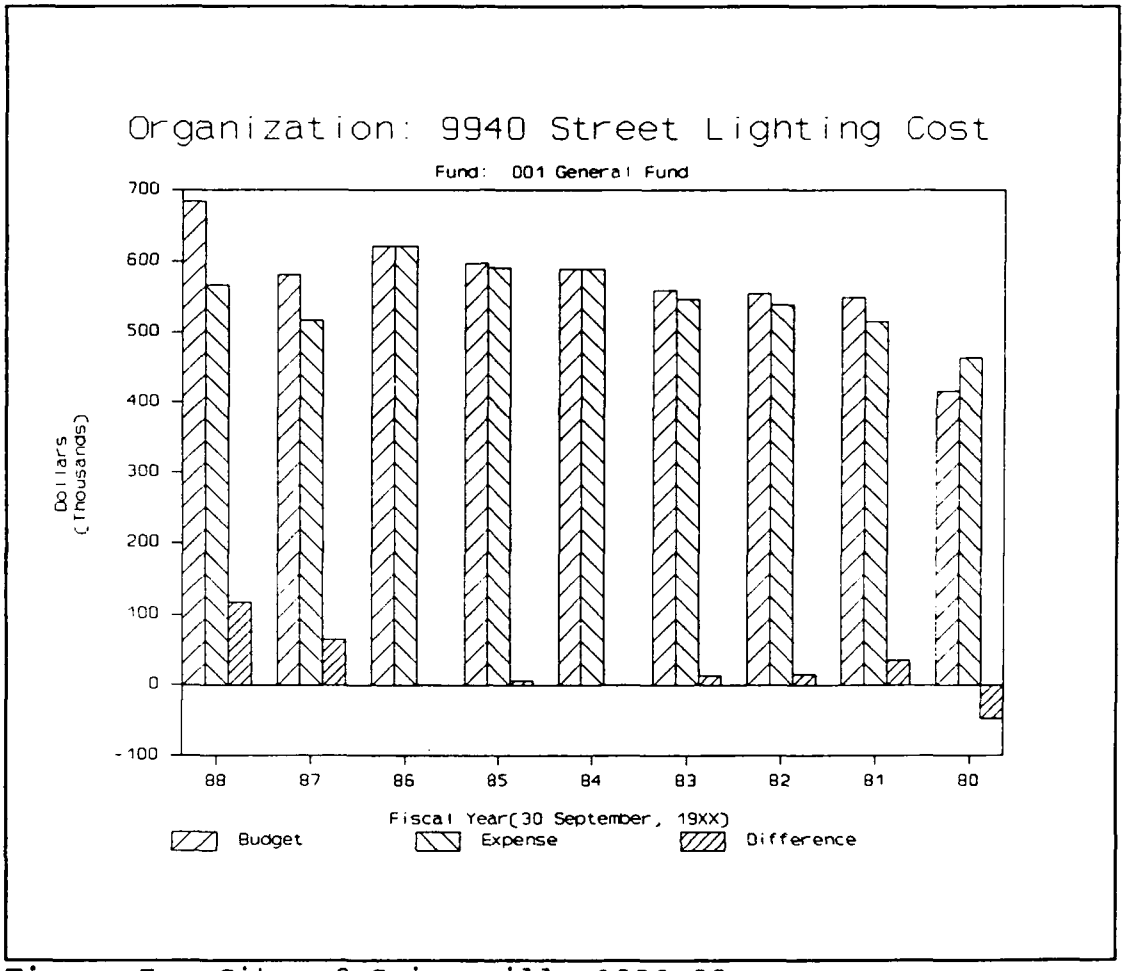

Figure 7 - City of Gainesville 1980-88

4.5.2 Light Funding & Oversight - FDOT

On FDOT projects, lighting designs and costs are forwarded to the FDOT regional district in Lake City for approval. Due to a recent Governor's order, all FDOT authority, which formerly and solely resided in Tallahassee, is currently being decentralized. Consequently when in the past designs were forwarded to Tallahassee, they are now approved at the regional districts. Needless to say, Lake City currently does not have a trained electrical engineer

or technician to review the sufficiency of the designs. Although they ask FDOT Tallahassee for guidance while they train a member of their staff, Tallahassee's staff has been trimmed to act only as a quality assurance coordinator of state lighting initiatives. Essentially no design review is being conducted. However Lake City does have programs to insure justification and funding of the project is sufficient. In fact the lighting justification program, programmed several years ago at University of Florida for FDOT, evaluates the proposed life cycle costs of the project against anticipated cost savings in fewer accidents based on provided project costs, traffic flow, accident rates and costs of damage(not including loss of life). Unfortunately, to the knowledge of Lake City's Safety Engineer, Mr Earl Hodges, the program has only once not justified a project.[23]

4.5.3 Energy Advisory Committee

The City, in regards to energy issues, also employs the Energy Advisory Committee(EAC) which is a volunteer group meeting monthly and was appointed to provide recommendations for active conservation programs as an alternative to

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[23] Based on my inquiry, the 39th Ave lighting design performed by a GRU technician was only checked, as mentioned, by the lighting justification program and approved for funding. Since FDOT Lake City currently has no trained lighting engineers on staff, no apparent design review occurred. This raises serious questions involving liability arising from no professional design oversight.

building new utility generating capacity. Based on discussions with EAC's representative from GRU, an energy analyst, and attending a monthly meeting with EAC, little has been accomplish recently with their efforts. In fact at the meeting, most incumbent members agreed with one who said, "energy isn't on the front burner". Since this was the first meeting of newly appointed Committee members, I heard a historical rendition of EAC's accomplishments as well as gained insight into their perceived obstacles. They agreed with Mr Mario Rivera who felt the energy element wasn't being taken seriously with repeat "No Action" being taken on many key issues. They felt the City lacked long term goals such as the ongoing Energy Emergency Planning. One interesting note was the board's capitalizing on a state program to fund an energy engineer in local government to institute long range goals in county and city government for a two year period. Unfortunately the board could not convince the previous City Manager, now resigned, to hire one on staff perhaps partly because the state would only reimburse for two years worth of costs. Consequently, the board acceded to contracting with a local consultant(Ingle, Campbell and Moses) for two years to provide recommendations to the Energy Element and provide long term goals for the City. Finally in discussions with GRU's energy analyst, I was reminded that street lighting was an off-peak load. My assumption is that although energy conservation is important

to everyone in Gainesville, including the utility, efforts to reduce off-peak loads do not help the utility in their efforts to control generating capacity which is dictated by peak loading and therefore is time ill spent. Although saving fuel is important, the beneficiary of reducing off-peak loading, in this case lighting, would be the City with it's 85,000 citizens.

CHAPTER FIVE
OBSERVATIONS & RECOMMENDATIONS

5.1. Currently no review of lighting requests is occurring. Most calls are forwarded by GRU lighting repair to GRU's Lighting Technician although some, more urgently, come from City officials through the chain of command. This factor is indicative of the lack of a coherent city-wide policy for lighting design. I strongly recommend the convening of relevant officials within GRU and the City in drafting a comprehensive lighting policy, approved by the commission, that can be budgeted and executed.

Background: With the current absence of lighting policy, approved by the commission, GRU personnel are executing debatable and varying criteria in the maintenance and promotion of the City's lighting system. As is clearly stated in the 1981 Lighting Conversion Report and in discussions with officials in Tallahassee, this lack of approved standards elevates liability questions surrounding current practice. From the 1981 Report, "decisions of how much light to provide is a discretionary function with tort immunity, acts of carrying out these plans are not, so the most serious risks are with misapplication of lights(installing lights where they cause blinding glare or obscure traffic signals or obscure road hazards) and negligent maintenance." To complicate this situation is the

professional registration questions that arise with the design of lighting by technicians. Furthermore according to FDOT Tallahassee, in the absence of policy guidelines that reflect the best lighting the City would economically require or in regards to contingency lighting plans, serious culpability considerations arise.

In designing a City lighting plan, close consultation with the City Attorney should have occurred. The policy should embrace current guidelines such as AASHTO or IES as a framework.[24] In my opinion the City should not advance a policy of attempting to light the whole City, but should embrace progressive and economical warranting programs as outlined in the Department of Transportation Roadway Lighting Handbook.[25] The City of Carmel lights only the business areas while Portland, Oregon embraced a comprehensive plan to light conflict areas(intersections etc), recommended specific standards while avoiding certain techniques and basically provided a relevant, safe, and energy conscious approach. Other recent national initiatives include the pursuit of transition lighting,

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[24] As discussed previously, current IES standards might be reconsidered.

[25] Warranting roadways is a procedure outlined in the Handbook involving field inspections of all roadways whether lighted or not and through a series of questions covering geometric, operational, environmental and accident factors ascertains a weighing system that managers can balance available resources to prioritized lighting needs throughout a complete system. See Appendix J.

normally used in tunnels, between lit conflict areas. The plan should find some reference to security criteria, which I could not find, other than the police departments repeated requests for more light in neighborhoods.[26] Finally the plan should closely address fringibility of poles along right of way in regards to their intimate relationship of accidents through collision. Currently many citizens, the community and commission forces influence, purposely or not, light design and selection at GRU(See Figure 8). Citizens, as discussed, are permitted to call the lighting division at GRU directly, with their requests both City and County wide. In the City, the Traffic Engineer established the tone by saying, "Street lighting is a public right as long as it meets the criteria of the utilities". According to GRU, calls are "all requests" but with a lack of city-wide standards there is no arbitration of citizen lighting

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[26] Various police personnel currently call Mr David Lea at GRU for lighting throughout the City. These arise from requests made by the Crime Prevention Unit, officers investigating crime scenes and various patrol officers in the performance of there normal duties. No screening process for lighting requests is exhibited by the Department since GRU attempts to grant each request. In discussions with Sgt Gerard and Captain Mitchel, wide views are held by officers within the Police Department in just how important lighting is in fighting crime. Efforts to gather information concerning lighting and it's affect on crime in the City were wasted when research in the large SE 15th Street Lighting Project could not be tracked since comparative data was lost prior to January 1989, according to Capt Mitchel. The 1979 Department of Justice Report on Street Lighting Projects and it's effect on crime reveal inconclusively the importance of lighting in crime prevention or displacement.

grievances which results in varying lighted stretches of road in the City. The Lighting Task Force, a concept founded by Commissioner Long with a mandate by the community, held meetings with GRU, the police department and others in early 89' regarding his efforts to light up an area within his purview. Against good engineering judgement, the plan threatens to light areas in excess of design standards, involving serious light trespassing on the closely packed homes with considerable dispersion and wasted illumination in the myriad of trees. Reportedly GRU officials are drafting a letter to the commission to explain their involvement in determining City lighting policy. Furthermore contingency plans are not devised to address runaway utility costs that pervaded the last energy crisis as demonstrated by the snail's pace of EAC's Energy Emergency Plan. These issues could be averted if GRU officials and the Commission had an approved City Lighting Plan.

THE CITY COMMISSION SHOULD ASSEMBLE ALL CITY WIDE LIGHTING PARTIES MENTIONED IN THE REPORT TO ADOPT A STANDARD(IES, AASHTO,ETC) FOR GRU AND THE CITY. BASED ON RESULTS IDENTIFIED IN APPENDIX B, A SENSITIVITY ANALYSIS FOR LIGHTING IN GAINESVILLE, CITY-WIDE EFFORTS CAN BE CONCENTRATED IN BOTH STREET LIGHTING PLANNING AND DESIGN. LIGHTING PLANNING SHOULD BE DEVELOPED WHERE THE CITY TRAFFIC ENGINEERING DEPARTMENT BUDGETS, WARRANTS AND REQUESTS GRU TO

DESIGN AND PLACE CITY LIGHTING IN PRESCRIBED LOCATIONS BASED ON ACCEPTED STANDARDS. THE CITY TRAFFIC ENGINEERING DEPARTMENT BASE PLANNING ON WARRANTING PROCEDURES, AS OUTLINED IN APPENDIX A-6, WITH SIGNIFICANT WEIGHT BEING ALLOCATED TO HIGHER AVERAGE DAILY TRAFFIC FLOW ROADS, HAZARDOUS AREAS IDENTIFIED BY FDOT UNDER ACCIDENT REDUCTION FACTORS, AND HIGH NIGHT ACCIDENT RATE ROADS. GRU DESIGN BRANCH SHOULD CONCENTRATE EFFORTS ON MAXIMIZING POLE SPACING, MAXIMIZING FRINGIBILITY, MINIMIZE LAMP WATTAGES, INCREASE LUMINAIRES PER POLE BY CONSIDERING MOUNTING POLES IN PROTECTED MEDIANS AND INCREASING OVERALL MOUNTING HEIGHTS. ALL OTHER DEPARTMENTS(INCLUDING POLICE) SHOULD WORK WITH TRAFFIC IN ESTABLISHING THEIR LIGHTING PECKING ORDER. ALL PARTIES SHOULD ESTABLISH A CITY LIGHTING BOARD BY EDICT THAT MEETS PERIODICALLY TO ESTABLISH A CONSENSUS AMONG PARTIES.

5.2. Currently one EET2 is accomplishing design planning of all public lighting in the City, although this is a credit to the individual's diligent and productive efforts, other alternatives should be considered based on engineering professional registration standards, noted omissions in current engineering design and the complexity of lighting design.

Background: With the increasing complexity of lighting

design and the demonstrated poor oversight of existing plans by both the State, City and GRU officials, professional engineering guidance should be more often sought in lighting design. One conclusion of the 1981 Roadway Lighting Conversion Report, although self serving in recommending future consultant work, cites lack of in-house know-how, lack of personnel commitment and the increasing complexity of lighting as consideration in retaining a consultant or gearing up in-house capabilities, both computer and employee. In my opinion, this could be resolved by one of the following:

A. Establish a full time, electrical or mechanical engineer as the energy coordinator, working strictly for the City who would review and approve lighting requests among other duties. If the Benefit to Cost does not justify this option, consider choice B.

B. Contract out not only all city-wide lighting design efforts but perform periodic reviews and updates to city lighting policy. Since the last review in 1981, lighting within the city has changed.

C. Gear up current in house lighting design efforts both in computer hardware and software. Encourage Traffic Engineering Department to hire a lighting technician with a specific mandate to serve the department's interests.

Mr Lester Jones, FDOT Tallahassee, believes many cities establish contracts with local consultants who are knowledgeable and reasonably priced in lighting design work. Furthermore he felt lighting seminars, held annually by all lighting manufacturers, should be a annual training requirement for in house personnel. However he felt more technical issues of ballast, wiring and electrical design

required more traditional forms of education and were best addressed through consultants. The present outdoor lighting technician at GRU is doing an incredible job trying to overcome the monumental workload that includes normal duties as well as additional managerial decision-making in excess of his position. However with the recent arrival of Mr Beaulieu, Electric Engineering Manager, momentum towards better lighting design and guidance can expect improvement.

IN SPITE OF THE ELECTRIC SYSTEM OPERATIONS DIRECTOR'S REMINDER OF THE EMINENT DOMAIN EXHIBITED BY GOVERNMENT, IMPROVEMENTS IN LIGHTING DESIGN OF ROADWAYS SHOULD BE CONSIDERED BY ESTABLISHING A SERVICE CONTRACT WITH PROFESSIONALS WHO UNDERSTAND CURRENT STANDARDS AND ARE MORE AWARE OF LIABILITY. IN HOUSE LIGHTING EFFORTS SHOULD BE BEEFED UP WITH BETTER AND CONTINUOUS TRAINING OF ALL PERSONNEL. THE TRANSFER OF MANAGING THE LIGHTING FOR THE CITY SHOULD BE RETURNED TO THE CITY TRAFFIC ENGINEERING DIVISION FOR SPECIFIC GUIDANCE THEREBY RELIEVING THE LIGHTING TECHNICIAN TO ADDRESS DESIGN AND EXECUTION OF EXPECTED LIGHTING DUTIES. FINALLY, IES OR AASHTO STANDARDS SHOULD BE QUICKLY ADOPTED BOTH GRU AND CITY WIDE WITH ALL OTHER STANDARDS BEING ABOLISHED IN FAVOR TO A STRICT OBSERVANCE TO ONE STANDARD. WHEN THIS STANDARD IS ADOPTED CHANGES SHOULD BE MADE TO THE ZONING BOARD ORDINANCES AND ALL OTHER ORDINANCES. REMEMBER, WRESTLING WITH VARIOUS STANDARDS IN ATTEMPTING TO ADOPT THE BEST ONE IS FRUITLESS

IN THE ABSENCE OF ANY CITY-WIDE STANDARDS.

5.3. Undertakings by GRU lighting crews, since at least 1984, replacing higher wattage mercury vapor lighting with lower wattage high pressure sodium, as was recommended by the Roadway Lighting Conversion Report in 1981, should be continued with a goal of eliminating all mercury vapor lighting throughout the City as an appropriate schedule.

Background: Previously GRU has been replacing high energy consuming mercury vapor lighting and replacing them with more economical high pressure sodium lighting. Unfortunately according to GRU's monthly Lighting Summary billed the City, **285-175 watt, 778-400 watt and 156-1000 watt mercury vapor lamps have not been replaced.**[27] This is due in part to the perception of a lack of commitment by the City leadership in converting to a more energy efficient lighting system This is based in part, according to one official at GRU, on the adoption of the 1981 Roadway Lighting Conversion Report by the City Commission, but no official actions were taken to carry out the

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[27] Since GRU doesn't really know how many lights are actually in it's system, all lighting summaries are noted by "Inventoried not complete as of 5/22/89, Quantity estimated discrepancy of + 10 %". Although the much heralded GEOMAX system will be updated with respect to lighting shortly(other areas still outstanding), validating the relational database and downloading it to a useable format for billing could be months or years away.

recommendations. With no official process for City Lighting, City officials could insure specific lighting requests were acted in spite of sound judgement. This is evident in the City Lighting Task Force, which discussed in recommendation #4, forces a disproportionate and questionable allocation of lighting resources to a select community. In the absence of a lighting strategy one should not be surprised that public officials attempt to further their representative interests without being aware of its implications.

Generally, the GRU design branch technician has come a long way in **attempting to do the conversion single handedly**, however in my view, much more could be done if management supported efforts to convert to energy efficient HPS systems. Also, the mere fact that MV lights are retained indicates individual considerations might sometimes prevail over good policy. Ultimately, these conversion efforts do raise important questions in regards to liability in the absence of official directives as will be seen in the next four recommendations. HPS CONVERSION SHOULD BE SANCTIONED AND ASSISTED BY GRU AND CITY MANAGEMENT IN REDUCING OPERATIONAL COSTS OF LIGHTING.

5.4. Have the City Auditor review and make recommendations in regards to billing procedures for #9940 Street Lighting Costs, of the non-departmental account

within the General Fund, between the City Traffic Engineering Department and GRU.

Background: No authority is being exercised in managing the City's Street Lighting Costs through the Traffic Engineering Department. Although they program the budget from year to year, there is no accounting of lighting usage against costs. This is in large part due to GRU's inability to account for individual street lights throughout their system(City, County, & commercial). Therefore the city should be skeptical in relating expenditures to City owned Lighting. According to Ilene Mazak, City Auditor's Department, there has been no recorded audit of the Traffic Engineering Department or organization: 9940 Streets Lighting Costs. THE CITY AUDITOR'S DEPARTMENT COULD PROVIDE INSIGHT INTO BETTER BILLINGS OF LIGHTING BY GRU TO THE CITY.

5.5. Contract with ILLUME who drafted the 1981 Roadway Lighting Conversion Report to update their report as well as provide new recommendations to the City.

Background: ILLUME in Oregon performed the last study in 1981. That report was instrumental in GRU's single-handed efforts to improve city-wide lighting as well as to keep the city abreast of changing conditions. Funds may be available from the state in their two year energy adviser program to

deal with outdoor lighting that the current contract with Ingle, Campbell and Moses does not cover. ILLUME HAS THE CORPORATE KNOWLEDGE TO REEVALUATE CITY LIGHTING AT GRU AND COMMENT ON ACTUAL PROGRESS THAT HAS BEEN ACCOMPLISHED SINCE 1981. FEW COULD PROVIDE THE INSIGHT OF EIGHT YEARS OF PROGRESS.

5.6. Although the EET2 in GRU went to the GE lighting school in 1985, efforts should be made available to encourage other manufacturer schools (Holofane, Sylvania etc) and coop programs with FDOT Tallahassee.

Background: Although GRU's lighting technician has 5 years experience, some under graduate engineering studies at FSU, and a forthcoming management degree from Nova University. His knowledge of lighting is heavily based on a GE lighting school attended in 1985. FDOT Tallahassee recommended an active training program for those involved in the progressive and technical lighting field. Lake City currently has a full time electrical engineer in training for strictly lighting. More specific training could be discussed with Mr Lester Jones in Tallahassee, FDOT Lighting, at 487-3276. ENCOURAGE MORE AND CONSISTENT LIGHTING TRAINING FOR GRU'S LIGHTING TECHNICIAN.

5.7. The City Hazardous Waste Coordinator should

review current practices of disposing of high efficacy light luminaries.

Background: Some questions are raised in the normal disposal of heavy metal laden, high efficacy luminaries. One of Low Pressure Sodium lighting's leading deficiency, indicated by both the Roadway Lighting conversion Report and GRU, arise over disposal issues. Surprisingly this is not an argument in the disposal of metal halide, mercury, or other sodium lights(HPS) which "reportedly" have lower, individual quantities of heavy metals. However the disposal of many light fixtures over time, in the quantities generated by GRU servicing the City and County, would seem to concentrate this type of waste in normal dumping areas. THE CITY HAZARDOUS WASTE COORDINATOR SHOULD EXAMINE DISPOSAL PRACTICES OF HIGH EFFICACY LAMPS.

5.8. Low Pressure Sodium(LPS) lighting considerations should be revisited by GRU, to tentatively determine if its use would warrant the cost savings and consistent lighting levels not attained by other sources.

Background: As early as 1981, GRU decided to not consider the installation of higher efficacy LPS lighting. This was in part due to the monochromatic nature of the light causing a lack of perceived public support as well as unresolved

disposal questions according to GRU. This decision, when questioned, does not reflect substantiated judgement or study and is always a result of peoples opinions. However, this decision process isn't endemic to just GRU, my literature searches were not sufficient to determine validity for either case. Further study should be made through research or experimentation to actually see if the cost savings are significant in relation to the publics perceptions. Arguing the case of non-public support for modern lighting is more relationship to a lack of effort than to any real public problems, see Appendix A-7. Low Pressure Sodium lighting, at great savings to the City, could be accomplished in City owned areas or commercial districts where the public may have no interest in the light color. Figure 1 established the significant advantage of LPS systems over HPS in lower energy usage. Some portion's of the 1981 Roadway Lighting Conversion Report establish a good case for proper consideration of the lights superior efficacy ratings.[28] REINVESTIGATE LPS SYSTEMS FOR CITY

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[28] The 1981 Roadway Lighting Conversion Report concluded with, " While LPS is proper in some cities and applications, we again stand firm by our recommendations for HPS in cut-off luminaires for the City of Gainesville." This decision was based on two main considerations. First as previously mentioned, the Report perceived the persuasive citizenry involvement in the detracting monochromatic nature of the light coupled with the lack of commitment by GRU and the City. Second, "If LPS or any other product is to be considered further, spend the money for a full and proper evaluation. If not, stand by your decision firmly." Unfortunately, GRU did not conduct a study.

USAGE. EXPERIMENTATION SHOULD BE COUPLED WITH A STRONG PUBLIC ACCEPTANCE OF THE PLAN AS DEMONSTRATED IN APPENDIX A-8.

5.9. Lighting Ballasts, which includes the wiring, capacitor, electronic spike unit and transformer that converts line to light voltage, have changed exceptionally in recent years. An investigation should be made to determine the most economical system for use in Gainesville.

Background: Other than through normal field investigations and maintenance, GRU's lighting ballasts have not been technically investigated to determine ideal composition. As seen in Appendix A-9 and as recommended in the 1981 Roadway Lighting Conversion Report, optimum ballast selection could extend the lamp life and reduce lamp failures. The excessive technical considerations preclude an acceptable review by anyone less than an expert and/or consultant. No comprehensive study has been performed by GRU despite recommendations made in the 1981 Roadway Lighting Conversion Report. AN OUTSIDE CONSULTANT SHOULD INCLUDE IN IT'S REVIEW OF CITY LIGHTING, OPTIMUM BALLAST AND LUMINAIRE DESIGN.

5.10. A renewed study of the listing of recommended manufacturers by GRU of lighting equipment and materials should be considered.

Background: Although current equipment choices are determined by the GRU design and maintenance branch. Periodic reviews of these listings are essential to insure life cycle cost data is considered along with ease of installation and maintainability. Instead, in the absence of an oversight committee, complete and objective consideration of the entire life cycle costs of equipment is ignored in favor of maintainability and ease of installation. Although the 1981 Roadway Lighting Conversion Report is dated, manufacturer equipment recommendations differ with current purchasing practices. A sampling is shown:

ITEM	REPORT	CURRENTLY
HPS	Gardco, GE	GE, Sylvania, Phillips etc
MV	None	GE, Sylvania, Phillips etc
MH	Sylvania, GE	Kim
Photocell	Fischer Pierce	Sunswitch

AN OUTSIDE CONSULTANT SHOULD INCLUDE IN IT'S REVIEW OF CITY LIGHTING MATERIAL AND SUPPLIER CHOICES.

5.11. Establish a review committee or board that meets periodically to assemble all players in the City's lighting policy.

Background: Two offices at GRU currently review most lighting policy. As has been discussed, the design branch headed by a technician determines specific practices,

equipment utilization and maintenance planning. GRU energy analysts often provide far reaching energy generation capacity programs. These offices can come into conflict when they overlap without full knowledge of the others activities. In the 1988 Energy Element, GRU energy analysts "implemented" IES lighting standards without informing the actual branch who performs the work. Ironically in discussions of the composition of IES, those standards are actually in slight opposition to efforts of reducing energy consumption. MIS-COMMUNICATION AMONG ACTIVE CITY LIGHTING PARTICIPANTS IS A RESULT OF LACKING POLICY. GRU SHOULD MEET AMONG LIGHTING REPRESENTATIVES PERIODICALLY TO ESTABLISH CONSENSUS OF WORK, AS MENTIONED IN THE ESTABLISHMENT OF THE CITY LIGHTING BOARD.

5.12. The 1981 Roadway Lighting Conversion Report recommended a review of lighting rental rates that actually encouraged energy usage. A committee should be convened to review this recommendation and ascertain if efforts should be made to provide disincentives to commercial lighting requests through higher rates or more energy conscious light selections.

Background: Although MV and Cobra head Lighting is no longer available for installation by commercial users, the City is not precluded from their use. Also inefficient

flood lighting is still readily available for commercial use even though the 1981 Roadway Lighting Conversion Report recommended discouraging its use. Lighting offered for the city does not reflect reduced rates which might be expected of a large consumer and public enterprise. In fact the individual consumer is paying the same amounts as the City for energy. It is my opinion, that commercial users should subsidize City charges, thereby discouraging consumption as well as freeing up some of the City's General Fund within the Traffic Engineering Department. Although these practices may be with great forethought, some system of programmed review, with all parties, is necessary to insure continued foresight and mutual cooperation in strategy. UTILIZE EAC IN EVALUATING GRU'S LIGHTING RATES AND LIGHT TYPE LISTINGS IN RECOMMENDING ALTERNATIVES IN ADDRESSING ENERGY CONSERVATION.

5.13. As previously mentioned, a review of cost assumptions should be performed by GRU to validate lighting rate hypothesis.

Background: With life cycle durations of concrete and wood poles being the same and the continued rental of inefficient flood lights, questions arise about the logic of the cost structure and its intent. Many other factors involving the various "Notes" in enclosures B through E need written

justification. According to Mr Bob Davis, GRU Energy Analyst, GRU has initiated review of rate structures. Although a rate adjustment to GRU's lighting charges was adopted in 1984, comprehensive rate breakdown and formulation has not been done since 1982. AS ANOTHER PROJECT FOR A UF GRADUATE STUDENT, REVIEW LIGHTING RATES AND GATHER ASSUMPTIONS IN IT'S FORMULATION TO DETERMINE IF THEY APPROXIMATE WHAT IS BEING CHARGED.

5.14. Efforts to put all lighting information on an <u>accessible</u> database for the lighting technician's interactive use should be redoubled. No encompassing system exists to analyze city-wide lighting data.

Background: Over the past three years, the City has been putting all as-built drawings on the GEOMAX system. One of the overlays that is being currently loaded to the City's site layout is the electrical system to include lighting. Each light is annotated and when recalled by its corresponding number reveals information covering all beneficial usages. Once this is loaded on GEOMAX, the database should be downloaded to a PC which is readily accessible to maintenance and design personnel. This system was encouraged by Tallahassee as well as recommended, in a non-computer version, in the 1981 Roadway Lighting Conversion Report. No reference system currently exists.

Consequently, analysis of specific site information with regard to maintenance, manufacturer or demographic data is nearly impossible to determine excepting an individual's personal memory. This current system has changed little since 1981. DOWNLOAD GEOMAX DATA INTO A DATABASE MANAGEMENT SYSTEM THAT CAN BE EASILY TRACKED BY LIGHTING PERSONNEL AND OTHERS AT GRU. GEOMAX CANNOT BE THE COMPLETE PANACEA AS ENVISIONED IF VARIOUS DEPARTMENTS CANNOT MANAGE THE DATABASE INDIVIDUALLY ON A CONTINUAL BASIS.

APPENDIX A
SUMMARY

A-1. FDOT Memorandum of Design Criteria For Highway Lighting Florida Department of Transportation, Design Criteria For Highway Lighting - Directive No 07-56, April 1978.
A-1. Florida Department of Transportation, Highway Lighting Plans - Guidelines, 1988.

Gainesville Regional Utilities, Public Street Lighting Rates, March 1989.

A-2. GRU's Lighting Available for Installation
A-3. GRU's Pole Charges
A-4. GRU's Annual Clean and Relamp Costs
A-5. GRU's Installation Costs

A-6. "Analyzing Lighting Needs." Roadway Lighting Handbook, December 1978, p. 12.

A-7. "Informed Public Supports Street lighting Modernization." Public Works, September 1985, p. 114.

A-8. "New Roadway Lighting Cuts Power Use." Public Works, December 1985, p. 43.

A-9. "Retrofit Ballast Kits Reduce Streetlight Conversion Costs." Public Works, March 1985, p. 87.

Appendix A-1 - 1978 - Dwsign Criteria For Highway Lighting

A-1

MEMORANDUM

State of Florida Department of Transportation

DATE April 18, 1978

TO District Traffic Operations Engineers and Consultants

FROM R. E. Magahey, State Traffic Operations Engineer

COPIES TO Mr. Jay W. Brown, Mr. P. W. Ekey, Mr. W. Gartner, Jr., Mr. P. J. White, Mr. A. C. Levingston, Mr. C. R. Miller, Mr. J. Crystal, Mr. R. Hock, Mr. B. Orth, Mr. Ken Courage, Mr. P. E. Carpenter, District Engineers & Fla. Urban Traffic Engrs. Council

SUBJECT DESIGN CRITERIA FOR HIGHWAY LIGHTING DIRECTIVE NO. 0747-56

This document outlines the basic highway lighting design criteria recommended and used by the Florida D.O.T., all previously issued illumination design criteria statements issued by this office are rescinded. The criteria presented is based on the AASHTO Guide For Roadway Lighting (latest edition) and that document should be consulted by designers for additional information during the design process.

AASHTO STANDARDS

Department of Transportation policy relative to highway lighting funding, implementation and maintenance is contained in Chapter 14-64, Rules of the Department.

The following criteria have been developed in consideration of the need to provide adequate street lighting while at the same time providing the most energy efficient lighting systems possible:

I. CONVENTIONAL ROADWAY LIGHTING (excluding rest areas & other special areas)

Light Sources: Cobra Head Luminaires
High Pressure Sodium --
400 W or Lower

Illumination Level:

Mainline L/A	: 1.0 average initial H.F.C.
Ramps	: 1.0 average initial H.F.C.
Crossroad	: 1.0 average initial H.F.C.
Urban Arterial	: 2.0 average initial H.F.C.

NOW DECREASED TO "1.5"

Uniformity: 3:1 to 4:1 Avg./Min.
10:1 or less Max./Min.

NOW ANYTHING "LESS THAN 4:1"

Luminaire Position:
M.H. of 40' Min - 400 W HPS
M.H. of 30' Min - 250 W HPS
M.H. of 25' Min - 150 W HPS

5' negative overhang is standard for right side, limited access facility pole locations at 20 feet offset.

Appendix A-1 - 1984 Highway Lighting Plans

1984 STANDARDS

HIGHWAY LIGHTING PLANS - GUIDELINES

I PURPOSE

The roles of the various offices involved in plans production are changing as the Department implements decentralization. The increased use of consultant forces for the development of plans is another factor influencing change in the plans production process. These factors coupled with the elimination of the final plans review process in the Central Office indicate the need for guidelines to be established for the development of plans. The purpose of these guidelines is to maintain uniformity and consistency in the plans production process as the responsibility becomes more dispersed. The plans production guidelines are to remain the same regardless of where in the State the project is located or who prepared the plans.

II STANDARDS

The engineer responsible for the design of a highway lighting project should be aware that the design must comply with various standards.

In addition to the Department's Standard Specifications, the following standards should be consulted.

(1) "AN INFORMATIONAL GUIDE FOR ROADWAY LIGHTING", AASHTO, 1984-- This is the basic guide for highway lighting. It includes information on warranting conditions and design criteria. Specific design criteria applicable in Florida is discussed in the next section of this guideline.

(2) "STANDARD SPECIFICATIONS FOR STRUCTURAL SUPPORTS FOR HIGHWAY SIGNS, LUMINAIRES AND TRAFFIC SIGNALS", AASHTO(DATE) -- This specification contains the strength requirements of the poles and bracket arms for the various wind loadings in the State as well as the frangibility requirements. All luminaire supports, poles and bracket arms must be in compliance with these specifications.

(3) "ROADWAY AND TRAFFIC DESIGN STANDARDS"(CURRENT YEAR) -- These standards are composed of a number of standard drawings or indexes which address specific situations which occur on a large majority of construction projects.

These standards are referenced on the plans Key Sheet as required. The standards when referenced become a part of the contract plans.

The Roadway and Traffic Design Standards are reviewed and updated if required on an annual basis.

III DESIGN CRITERIA

This section outlines the specific design criteria recommended and used by the Department for highway lighting. This criteria is based on the AASHTO Guide for Roadway Lighting (Section II).

Two points should be discussed and clarified before addressing the design criteria. First, the AASHTO Guide permits either the illuminance technique or the luminance technique to be used in the design of highway lighting. The luminance technique requires a more complex design process and a knowledge of the reflective characteristics of the pavement surfaces used. These reflective characteristics change as the pavement ages and with changes in the weather conditions. The Department has elected to retain the

Appendix A-1 - 1984 Highway Lighting Plans - continued

illuminance technique for lighting design. Secondly, the design values for light levels given by the AASHTO Guide are maintained values. The light levels given in this criteria have been adjusted and are listed as average initial horizontal footcandles(H.F.C.). This, in effect, sets the maintenance factor to be used in the calculation process to a value of 1.

Mounting Height(M.H.) for conventional lighting is the vertical distance from the roadway to the light source regardless of lateral placement of the pole.

CONVENTIONAL LIGHTING

Illumination Level:

1978 - 2.0 →

Urban Arterials	1.5 average initial H.F.C.
All Other Roadways	1.0 average initial H.F.C.

Note: These values should be considered as minimum and desirable. Values as high as one and one-half the desirable values are allowed if necessary to maintain an acceptable uniformity level.

Uniformity:

1978 - 3 → 4:1

4:1 or Less	Avg/Min
10:1 or Less	Max/Min

Light Sources:

High Pressure Sodium	400 Watt or Less

Mounting Height Restrictions:

400 Watt HPS	40 FT. M.H. Min
250 Watt HPS	30 FT. M.H. Min
150 Watt HPS	25 FT. M.H. Min

HIGH MAST LIGHTING

Illumination Level:	0.7-0.9 average initial H.F.C. over the area
Uniformity:	
3:1 or Less	Avg/Min (on the roadway)
10:1 or Less	Max/Min
Light Sources:	
High Pressure Sodium	1000 Watt, 400 Watt
Mounting Height:	80 to 150 FT.(as design needs dictate)

POLE LOCATION OR SETBACK

Conventional Lighting:	(other than bridge or barrier wall mounted) Index 700 Roadway and Traffic Design Standards specify min. setbacks;however, a 20 ft. min. should be used where possible.

Appendix A-2 - Light Available for Installation

TABLE 2
GAINESVILLE REGIONAL UTILITIES
PUBLIC STREET LIGHTING
AVAILABLE FOR INSTALLATION

	TYPE 10	TYPE 11	TYPE 12	TYPE 13	TYPE 14	TYPE 15	TYPE 16	TYPE 17	[illegible]
	400 WATT FLOOD	100 WATT CUTOFF	250 WATT FLOOD	100 WATT AREA	150 WATT CUTOFF	150 WATT C/O DECO	[illegible] WATT CUTOFF	400 WATT MH DECO	40[illegible]
(1) INSTALLED COST OF LIGHT UNIT	412.65	377.32	421.48	303.34	383.06	550.[illegible]	[illegible]	[illegible]	-58[illegible]
(2) MONTHLY AMORTIZED COST	5.78	5.28	5.90	4.24	5.36	[illegible]	[illegible]	[illegible].45	[illegible]
(3) ENERGY USE KWH (ANNUAL)	1956	492	1236	492	792	792	[illegible]	1956	[illegible]
(4) ENERGY COST (ANNUAL)	47.45	11.94	29.99	11.94	19.21	19.21	[illegible]	47.45	47[illegible]
(5) DISTRIBUTION COST (ANNUAL)	22.81	5.74	14.41	5.74	9.23	9.23	14.41	22.81	[illegible]
(6) CLEAN AND RELAMP COST (ANNUAL)	4.38	3.75	4.21	3.75	3.85	3.85	4.21	4.38	4[illegible]
(7) TOTAL ANNUAL O&M	74.64	21.42	48.61	21.42	32.30	32.30	48.61	74.64	74[illegible]
(8) MONTHLY O&M COST	6.22	1.79	4.05	1.79	2.69	2.69	4.05	6.22	6[illegible]
(9) TOTAL MONTHLY COST OF SERVICE	12.00	7.07	9.95	6.03	8.05	[illegible].44	[illegible]	[illegible]	[illegible]
(10) CURRENT PUBLIC RATE	11.32	5.09	9.44	4.75	6.09	NA	[illegible]	NA	
(11) % DIFFERENCE TO COST OF SERVICE	[illegible]	27.97%	5.12%	[illegible]	[illegible]	NA	[illegible]	NA	

* AVAILABLE FOR CITY GOVERNMENT INSTALLATION ONLY.

NOTES:

(1) FROM APPENDIX 1.
(2) AMORTIZED 15 YRS @ 15%.
(4) ENERGY COSTS = 24.26 MILLS FROM 1988 C.O.S.
(5) DISTRIBUTION COSTS = 11.66 MILLS FROM 1988 C.O.S.
(6) FROM APPENDIX 3.
[illegible]
(8) (7)/12
(9) (2)+(8)

Appendix A-3 - Pole Charges

TABLE 1
GAINESVILLE REGIONAL UTILITIES
POLE CHARGES

		30' WOOD	35' WOOD	40' WOOD	30' CONC	35' CONC	40' CONC
(1)	MATERIAL	47.45	73.36	90.42	175.69	189.09	308.37
(2)	PURCHASING	1.90	2.93	3.62	7.03	7.56	12.33
(3)	ENGIN. LABOR	25.00	25.00	25.00	25.00	25.00	25.00
(4)	CENTRAL STORES	3.56	5.50	6.78	13.18	14.18	23.13
	SUBTOTAL	77.91	106.80	125.82	220.89	235.84	368.83
(5)	MONTHLY AMORTIZED COST	1.00	1.37	1.61	2.83	3.02	4.72
(6)	LABOR	65.00	65.00	65.00	65.00	65.00	65.00
(7)	EQUIPMENT	35.00	35.00	35.00	35.00	35.00	35.00
(8)	OVERHEAD LABOR	87.00	87.00	87.00	87.00	87.00	87.00
	SUBTOTAL	187.00	187.00	187.00	187.00	187.00	187.00
(9)	MONTHLY AMORTIZED COST	2.40	2.40	2.40	2.40	2.40	2.40
(10)	TOTAL MONTHLY COST OF SERVICE	3.39	3.76	4.01	5.22	5.42	7.12
(11)	CURRENT MONTHLY RATE	1.64	1.95	2.38	3.44	2.81	4.26
(12)	% DIFFERENCE TO COST OF SERVICE	51.67%	48.18%	40.60%	33.30%	48.11%	40.14%

NOTES:

(2) LESSER OF $40 OR 4% OF (1).
(3) 1 HR @ $25/HR.
(4) 7.5% OF (1).
(5) AMORTIZED 25 YRS @ 15%.
(6) 5 HRS @ $13/HR.
(7) 1 HR @ $35/HR.
(8) 87% OF (6) + 87% OF (7).
(9) AMORTIZED 25 YRS @ 15%.

Appendix A-4 - Clean and Relamp Costs

APPENDIX 3
GAINESVILLE REGIONAL UTILITIES
PUBLIC STREET LIGHTING
ANNUAL CLEAN AND RELAMP COSTS

FIXTURES AVAILABLE FOR INSTALLATION

		HIGH PRESSURE SODIUM (HPS)				METAL HALIDE (MH)	
		100 WATT	150 WATT	250 WATT	400 WATT FLOOD	150 WATT DECO	400 WATT DECO
(1)	LABOR	0.43	0.43	0.43	0.43	0.43	0.43
(2)	MATERIAL	2.57	2.36	2.70	2.86	2.36	2.86
(3)	EQUIPMENT	0.50	0.50	0.50	0.50	0.50	0.50
(4)	ADMINISTRATION	0.38	0.38	0.38	0.38	0.38	0.38
(5)	WAREHOUSE	0.17	0.18	0.20	0.21	0.18	0.21
(6)	TOTAL	3.75	3.85	4.21	4.38	3.85	4.38

FIXTURES NOT AVAILABLE FOR INSTALLATION

		HIGH PRESSURE SODIUM (HPS)			MERCURY VAPOR (MV)		
		70 WATT	250 WATT COBRA	400 WATT COBRA	175 WATT	400 WATT	1000 WATT
(1)	LABOR	0.43	0.43	0.43	0.43	0.43	0.43
(2)	MATERIAL	2.44	2.82	2.98	1.22	1.28	3.54
(3)	EQUIPMENT	0.50	0.50	0.50	0.50	0.50	0.50
(4)	ADMINISTRATION	0.38	0.38	0.38	0.38	0.38	0.38
(5)	WAREHOUSE	0.18	0.21	0.22	0.09	0.10	0.27
(6)	TOTAL	3.93	4.34	4.51	2.62	2.69	5.11

NOTES:

(1) ASSUMING 5 LAMPS/HR/6 YRS @ $17.76/HR.
(2) ASSUMING LAMP REPLACEMENT EVERY 6 YEARS.
(3) ASSUMING 5 LAMPS/HR/6 YRS @ $15/HR.
(4) 87% OF (1).
(5) 7.5% OF (2).

Appendix A-5 - Installation Costs

APPENDIX I
GAINESVILLE REGIONAL UTILITIES
INSTALLATION COSTS
PUBLIC STREET LIGHTING
AVAILABLE FOR INSTALLATION

	TYPE 10	TYPE 11	TYPE 12	TYPE 13	TYPE 14	TYPE 15	TYPE 16	TYPE 17	TYPE 18
	400 WATT FLOOD	100 WATT CUTOFF	250 WATT FLOOD	100 WATT AREA	150 WATT CUTOFF	150 WATT C/O DECO	250 WATT CUTOFF	400 WATT MH DECO	400 WATT CUTOFF
(1) FIXTURE	122.01	92.97	131.84	26.35	97.57	195.02	126.14	1179.15	185.00
(2) LAMP	17.16	13.66	16.25	12.66	14.16	14.16	16.25	14.54	17.16
(3) PHOTOCELL	4.51	4.51	4.51	4.51	4.51	4.51	4.51	4.51	4.51
(4) ARM	19.40	21.25	19.40	21.25	21.25	39.50	21.25	250.00	45.10
(5) CABLE & MISC.	28.41	28.41	28.41	23.41	28.41	28.41	28.41	28.41	28.41
(6) MATERIAL TOTAL	192.49	160.80	200.41	94.18	165.90	281.63	196.56	1476.61	280.18
(7) PURCHASING	7.70	6.43	8.02	3.77	6.64	11.27	7.86	40.00	10.41
(8) CONST. LABOR	32.50	32.50	32.50	32.50	32.50	45.50	32.50	52.00	32.50
(9) OVERHEAD	71.78	71.78	71.78	71.78	71.78	88.09	71.78	88.74	71.78
(10) EQUIPMENT	43.75	43.75	43.75	43.75	43.75	61.25	43.75	70.00	43.75
(11) CENTRAL STORES	14.44	12.06	15.03	7.06	12.44	21.12	14.74	110.75	19.51
(12) ENG. CONST. LABOR	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00	50.00
(13) INSTALLATION TOTAL	220.16	216.52	221.07	208.86	217.10	277.22	221.63	411.49	227.95
(14) TOTAL INSTALLED COST	412.65	377.32	421.48	303.04	383.00	558.85	418.19	1888.10	508.13

NOTES:

(1-5) WORKING PAPERS W/DATA SUPPLIED BY LIGHTING COORDINATOR.
(7) LESSER OF $40 OR 4% OF (6).
(8) $13/HR.
(9) 87% OF (6) + (12).
(10) $35/HR.
(11) 7.5% OF [illegible].

Appendix A-6 - Street Light Warranting

Efforts by Gainesville planners in determining street lighting needs by prioritization seems daunting. However, methods of warranting developed by the U.S. Department of Transportation in their 1978 Roadway Lighting Handbook offer insight into both grasping and managing City street lighting. Since City street lighting is a subset of street lighting within the federal governments purview, relevant parts of the Handbook are offered in helping to solve City lighting needs.

The City has three basic types of non-controlled access facility lighting areas: streets, highways and intersections. Within the guidelines of the warranting process both streets and highways are considered equally. In evaluating these areas four factors are considered: Geometric, Operational, Environmental and the Night Accident Rate. A matrix of these considerations are offered in Tables 1 & 2. Forms 1 & 2 quantify these considerations and weigh each according to the relative importance according to the Federal Highway Administration's ranking. Since virtually all relevant considerations are present on the forms, City officials could change the relative weights to fit it's needs. For example the crime rate could be valued at .75 instead of the current difference of .5. However before field inspectors go to the field to inspect street lighting whether existing or under consideration an Information al form should be filled out to cover the proposed inspection area as can be seen in Table 3. After inspection of all City streets warranting conditions are established for each area as can be seen in the sample Form 1.

Since these warranting conditions do not reflect the relative importance among several inspection areas in regards to the number of lanes, affected miles of roadway or the relative lighting levels from the design condition. A priority index is offered to rank all choices based on the following formula:

$$Px = \frac{E \times NADT/n \times L \times W/F}{AC}$$

Where:

- Px = Priority Index
- E = Total Warranting Points
- NADT = Night Accident Rating
- n = Number of Lanes
- L = Affected Lane Miles
- F = Actual Design Level of Average Illumination
- W = Warranting(min) Level of Average Illumination
- AC = Annual Cost

After identifying each areas priority index, a ranking can be developed and managers may allocated limited resources most effectively.

Appendix A-6 - Street Light Warranting

TABLE 1

VISUAL INFORMATION NEEDS TO BE SATISFIED
BY FIXED ROADWAY LIGHTING

Non-Controlled Access Facilities	Controlled Access Facilities
Roadway geometry	Roadway geometry
Roadway surface	Roadway surface
Roadway objects	Roadway objects
Roadway edge	Roadway edge
Roadway markings	Roadway markings
Signs	Signs
Signals	Signals on crossroads
Delineation	Delineation
Intersection location	Intersection location
Channelization outline	Channelization outline
Access driveways	Curb locations
Shoulders	Shoulders
Roadside objects	Roadside objects
Curb locations	Vehicles on facility
Vehicles on facility	Vehicles on interchanging facilities
Exit, entrance, and crossing vehicles	Pedestrians
Pedestrians	Ramp entrances
Pedestrian crosswalks	Ramp exits
Sidewalks	Merge points
	On-ramp geometry
	Off-ramp geometry

Appendix A-6 - Street Light Warranting

TABLE 2
A-6
TRAFFIC FACILITY CHARACTERISTICS PRODUCING OR CONTRIBUTING TO VISUAL INFORMATION NEEDS

Type	Geometric	Operational	Environmental
Streets and Highways	Number of lanes Lane width Median openings Curb cuts Curves Grades Sight distance Parking lanes	Signals Left-turn signals and lanes Median width Operating speed Pedestrian traffic	Development Type of development Development setback Adjacent lighting Raised curb medians
Intersections	Number of legs Approach lane width Channelization Approach sight distance Grades on approach Curvature on approach Parking lanes	Operating speed on approach Type of control Channelization Level of service Pedestrian traffic	Development Type of development Adjacent lighting
Freeways and Expressways	Number of lanes Lane width Median width Shoulders Curves Slopes Grades Interchanges	Level of service	Development Development setback
Interchanges	Ramp types Channelization Frontage roads Lane width Median width Number of freeway lanes Main lane curves Grades Sight distance	Level of service	Development Development setback Crossroad lighting Freeway lighting

Appendix A-6 - Street Light Warranting

FORM I

EVALUATION FORM FOR NON-CONTROLLED ACCESS FACILITY LIGHTING

A-6

CLASSIFICATION FACTOR	RATING 1	2	3	4	5	UNLIT WEIGHT (A)	LIGHTED WEIGHT (B)	DIFF. (A - B)	SCORE (RATING X (A - B))
Geometric Factors									
No. of lanes	4 or less	-	6	-	8 or more	1.0	0.8	0.2	
Lane Width	> 12'	12'	11'	10'	< 10'	3.0	2.5	0.5	
Median Openings Per Mile	< 4.0 or one-way operation	4.0 - 8.0	8.1 - 12.0	12.0 - 15.0	> 15.0 or no access control	5.0	3.0	2.0	
Curb Cuts	< 10%	10-20%	20-30%	30-40%	> 40%	5.0	3.0	2.0	
Curves	< 3.0°	3.1 - 6.0°	6.1 - 8.0°	8.1 - 10.0°	> 10°	13.0	5.0	8.0	
Grades	< 3%	3.0 - 3.9%	4.0 - 4.9%	5.0 - 6.9%	7% or more	3.2	2.8	0.4	
Sight Distance	> 750'	500 - 700'	300 - 500'	200 - 300'	< 200'	2.0	1.8	0.2	
Parking	prohibited both sides	loading zones only	off-peak only	permitted one side	permitted both sides	0.2	0.1	0.1	
							Geometric Total		
Operational Factors									
Signals	all major intersections signalized	substantial majority of intersections signalized	most major intersections signalized	about half the intersections signalized	frequent non-signalized intersections	3.0	2.8	0.2	
Left Turn Lane	all major intersections or one-way operation	substantial majority of intersections	most major intersections	about half the major intersections	infrequent turn bays or undivided streets	5.0	4.0	1.0	
Median Width	30'	20 - 30'	10 - 20'	4 - 10'	0 - 4'	1.0	0.5	0.5	
Operating Speed	25 or less	30	35	40	45 or greater	1.0	0.2	0.8	
Pedestrian Traffic at Night (persons)	very few or none	0 - 50	50 - 100	100 - 200	> 200	1.5	0.5	1.0	
							Operational Total		
Environmental Factors									
% Development	0	0 - 30%	30 - 60%	60 - 90%	100%	0.5	0.3	0.2	
Predominant Type Development	undeveloped or back-up ramps	residential	half residential &/or commercial	industrial or commercial	ramp industrial or commercial	0.5	0.3	0.2	
Setback Distance	> 200'	150 - 200'	100 - 150'	50 - 100'	< 50	0.5	0.3	0.2	
Advertising or Area Lighting	none	0 - 40%	40 - 60%	60 - 80%	essentially continuous	3.0	1.0	2.0	
Raised Curb Median	none	continuous	at all intersections	at signalized intersections	a few locations	1.0	0.5	0.5	
Crime Rate	extremely low	lower than city average	city average	higher than city average	extremely high	1.0	0.5	0.5	
							Environmental Total		
Accidents									
Ratio of Night-to-Day Accident Rate	< 1.0	1.0 - 1.2	1.2 - 1.5	1.5 - 2.0	2.0*	10.0	2.0	8.0	
							Accident Total		

*Continuous lighting warranted.

GEOMETRIC TOTAL = _____
OPERATIONAL TOTAL = _____
ENVIRONMENTAL TOTAL = _____
ACCIDENT TOTAL = _____
SUM = _____ POINTS
WARRANTING CONDITION = 25 points

-60-

Appendix A-6 - Street Light Warranting

FORM 2

EVALUATION FORM FOR INTERSECTION LIGHTING

A-6

CLASSIFICATION FACTOR	RATING 1	2	3	4	5	UNLIT WEIGHT (A)	LIGHTED WEIGHT (B)	DIFF. (A - B)	SCORE [RATING X (A - B)]
Geometric Factors									
Number of Legs		3	4	5	6 or more (including traffic circles)	3.0	2.5	0.5	____
Approach Lane Width	> 12'	12'	11'	10'	< 10'	3.0	2.5	0.5	____
Channelization	no turn lanes	left turn lanes on major legs	left turn lanes on all legs, right turn lanes on major legs	left and right turn lanes on major legs	left and right turn lanes on all legs	2.0	1.0	1.0	____
Approach Sight Distance	> 700'	500-700'	300-500'	200-300'	< 200'	2.0	1.8	0.2	____
Grades on Approach Streets	< 3%	3.0 - 3.9%	4.0 - 4.9%	5.0 - 6.9%	7% or more	3.2	2.8	0.4	____
Curvature on Approach Legs	< 3.0°	3.0 - 6.0°	6.1 - 8.0°	8.1 - 10.0°	> 10°	13.0	5.0	8.0	____
Parking in Vicinity	prohibited both sides	loading zones only	off-peak only	permitted one side only	permitted both sides	0.2	0.1	0.1	____
							Geometric Total		____
Operational Factors									
Operating Speed on Approach Legs	25 mph or less	30 mph	35 mph	40 mph	45 mph or greater	1.0	0.2	0.8	____
Type of Control	all phases signalized (excl. turn lane)	left turn lane signal control	through traffic signal control only	4-way stop control	stop control to minor legs or no control	3.0	2.7	0.3	____
Channelization	left and right signal control	left and right turn lane signal control on major legs	left turn lane signal control on all legs	left turn lane signal control on major legs	no turn lane control	3.0	2.0	1.0	____
Level of Service (Load Factor)	A 0.0	B 0.0-0.1	C 0.1 - 0.3	D 0.3 - 0.7	E 0.7 - 1.0	1.0	0.2	0.8	____
Pedestrian Volume (peds/hr crossing)	very few or none	0-50	50-100	100-200	> 200	1.5	0.5	1.0	____
							Operational Total		____
Environmental Factors									
Percent Adjacent Development	0	0-30%	30-60%	60-90%	100%	0.5	0.3	0.2	____
Predominant Development near Intersection	undeveloped	residential	50% residential 50% industrial or commercial	industrial or commercial	strip industrial or commercial (no greenery)	0.5	0.3	0.2	____
Lighting in Immediate Vicinity	none	0-40%	40-60%	60-80%	essentially continuous	3.0	1.5	1.5	____
Crime Rate	extremely low	lower than city average	city average	higher than city average	extremely high	1.0	0.5	0.5	____
							Environmental Total		____
Accidents									
Ratio of night-to-day Accident Rate	1.0	1.0-1.2	1.2-1.5	1.5-2.0	2.0*	10.0	2.0	8.0	____
							Accident Total		____

*Intersection lighting warranted.

GEOMETRIC TOTAL • _____

OPERATIONAL TOTAL • _____

ENVIRONMENTAL TOTAL • _____

ACCIDENT TOTAL • _____

SUM • _____ POINTS

WARRANTING CONDITION • *5 points

Appendix A-6 - Street Light Warranting

TABLE 3 EXAMPLE INFORMATION FOR EVALUATION FORM	
(1)	Facility location: *Dallas, Harry Hines Blvd.*
(2)	Facility type: Divided arterial
(3)	Road length: 1 mile
(4)	Road width(s): 72'
(5)	Number of lanes (n): 4 - 12'
(6)	Affected lane-miles (L): 4
(7)	Design average daily traffic: 32,000
(8)	Design night average daily traffic (ADT_n): 8,000
(9)	Median openings per mile: 14.0
(10)	Curb cuts: 74%
(11)	Grades: 23%
(12)	Sight distance: 700'
(13)	No parking
(14)	One-half of intersections signalized
(15)	One-half of intersections have left turn bays with a volume of 6400 vph
(16)	Speed: 45 mph
(17)	Pedestrians per mile: 75
(18)	100% developed commercial - 150' setback
(19)	Continuous advertising lighting
(20)	Continuous raised curb median
(21)	Average degree of horizontal curves: 2.75
(22)	Low crime rate
(23)	1.5 accidents (night/day)

Appendix A-6 - Street Light Warranting

EXAMPLE FORM I

EVALUATION FORM FOR NON-CONTROLLED ACCESS FACILITY LIGHTING

CLASSIFICATION FACTOR	RATING 1	2	3	4	5	UNLIT WEIGHT (A)	LIGHTED WEIGHT (B)	DIFF. (A - B)	SCORE [RATING X (A - B)]
Geometric Factors									
No. of lanes	(4 or less)	-	6	-	8 or more	1.0	0.8	0.2	0.2
Lane Width	> 12'	(12')	11'	10'	< 10'	3.0	2.5	0.5	1.0
Median Openings Per Mile	< 4.0 or one-way operation	4.0 - 8.0	8.1 - 12.0	(12.0 - 15.0)	> 15.0 or no access control	5.0	3.0	2.0	8.0
Curb Cuts	< 10%	10-20%	20-30%	30-40%	(> 40%)	5.0	3.0	2.0	10.0
Curves	(< 3.0°)	3.1 - 6.0°	6.1 - 8.0°	8.1 - 10.0°	> 10°	13.0	5.0	8.0	8.0
Grades	(< 3%)	3.0 - 3.9%	4.0 - 4.9%	5.0 - 6.9%	7% or more	3.2	2.8	0.4	0.4
Sight Distance	(> 700')	500 - 700'	300 - 500'	200 - 300'	< 200'	2.0	1.8	0.2	0.2
Parking	(prohibited both sides)	loading zones only	off-peak only	permitted one side	permitted both sides	0.2	0.1	0.1	0.1
							Geometric Total		27.9
Operational Factors									
Signals	all major intersections signalized	substantial majority of intersections signalized	most major intersections signalized	(about half the intersections signalized)	frequent non-signalized intersections	3.0	2.8	0.2	0.8
Left Turn Lane	all major intersections or one-way operation	substantial majority of intersections	most major intersections	(about half the major intersections)	infrequent turn bays or undivided streets	5.0	4.0	1.0	4.0
Median Width	30'	(20 - 30')	10 - 20'	4 - 10'	0 - 4'	1.0	0.5	0.5	1.0
Operating Speed	25 or less	30	35	40	(45 or greater)	1.0	0.2	0.8	4.0
Pedestrian Traffic at Night (peds/mi)	very few or none	0 - 50	(50 - 100)	100 - 200	> 200	1.5	0.5	1.0	3.0
							Operational Total		12.8
Environmental Factors									
% Development	0	0 - 30%	30 - 60%	60 - 90%	(100%)	0.5	0.3	0.2	1.0
Predominant Type Development	undeveloped or back-up design	residential	half residential &/or commercial	industrial or commercial	(strip industrial or commercial)	0.5	0.3	0.2	1.0
Setback Distance	> 200'	150 - 200'	(100 - 150')	50 - 100'	< 50	0.5	0.3	0.2	0.6
Advertising or Area Lighting	none	0 - 40%	40 - 60%	60 - 80%	(essentially continuous)	3.0	1.0	2.0	10.0
Raised Curb Median	none	(continuous)	at all intersections	at signalized intersections	a few locations	1.0	0.5	0.5	1.0
Crime Rate	extremely low	(lower than city average)	city average	higher than city average	extremely high	1.0	0.5	0.5	1.0
							Environmental Total		14.6
Accidents									
Ratio of Night-to-Day Accident Rates	< 1.0	1.0 - 1.2	1.2 - 1.5	(1.5 - 2.0)	2.0*	10.0	2.0	8.0	32.0
							Accident Total		32.0

*Continuous lighting warranted.

GEOMETRIC TOTAL = _____
OPERATIONAL TOTAL = _____
ENVIRONMENTAL TOTAL = _____
ACCIDENT TOTAL = _____
SUM = _____ POINTS
WARRANTING CONDITION = 45 points

Informed Public Supports Street Lighting Modernization

DOUGLAS C. ZEFTING, P.E.
City Engineer,
Rochester, New York

NEIGHBORHOOD support is playing an important part in Rochester's four-year old street lighting modernization program. People tend to accept a project more readily when they have been advised of the reasons for it and know what to expect during the construction phase.

Over the next three years, the city plans to replace about 6,000 concrete and older metal poles with incandescent lighting on residential streets with city-owned and maintained 14-ft black fiberglass poles sporting a colonial-style luminaire with a 70-watt high-pressure sodium lamp. After the design for a particular area is complete, we notify residents that a public information meeting will be held. The city engineer and street lighting program coordinator are present, along with the city's design consultants. A slide presentation is shown, which includes a discussion of the costs and benefits of the program.

One reason the city decided to implement the Residential Street Lighting Modernization Program was concern over rising costs. Rochester's street lighting bill has increased from $2.7 million in fiscal year 1976 to $6.4 million in fiscal year 1983, or 140 percent over an eight-year period. Besides the rise in energy costs, a large portion of the increase is attributable to the leasing costs the city pays to the local utility — Rochester Gas & Electric — for the poles, cable, conduit, and lamps for its street lighting system numbering over 26,000 units.

By installing a city-owned and maintained street lighting system (including poles, luminaires, lamps, ble, and conduit) on many of its r dential streets, the city anticip saving $22.6 million over the nex years, or an average of $1.5 mil per year. The savings result prima from elimination of the leasing c for 25 percent of its street lighting s tem and the switch to the m energy-efficient light source. On our slides illustrates this point on a unit/per year basis. The cost operating a utility-owned and ma tained concrete pole/fixture combi tion runs $240, while a city-owned costs $80, a $160 savings per year street lighting unit.

Additional Factor

Another consideration that m vated the change was inadequ lighting levels. Many residen streets are considered underlit cause of the low output of the me descent fixtures. Producing only lumens for each energy dollar pended, incandescent fixtures ge ate a lighting level of only 0.2 f candle. On the other hand, the h pressure sodium lamps have an o put of 148 lumens for each do spent, resulting in a lighting leve 0.4 foot-candle, twice that of in descent.

Another important element o ered at each meeting is an expl tion of the construction that will oc in a neighborhood. A "mole" is u to bore under driveways, roadw and trees to minimize disruption a damage. All lawn areas that are d turbed are restored with topsoil a grass seed. The contractor is pe ized if work is not completed o city block within four weeks. A the lighting designs for each street available for review at the meet by residents. We try to address q tions and concerns people expres garding the program.

Since the city is now responsible maintaining these street lights, en maintenance and quality of mate were primary concerns. The dec tive colonial-style luminaire/fi glass pole combination was ch to facilitate upkeep and to cre uniform appearance on reside streets. A RSL-350 luminaire Manville's *Holophane Division* w be used because it provided th sired lighting level of 0.4 foot-c and is an easy-to-maintain unit vandal-resistant glass refractor signed to reduce glare on the s the luminaire facing the hous stead, the light is directed to the needing illumination — the s sidewalk, and tree lawn area starter is encapsulated and the b is a regulator type, features the feit were important.

■ **RESIDENTIAL street lights that were converted from incandescent lamps to high pressure sodium cost Rochester, New York only one-half as much to operate annually.**

PUBLIC WORKS *for Septemb*

lew Roadway Lighting Cuts Power Use

OT only does smoothly flowing traffic depend on the type of dway but, critically, on the ver's view of the overall traffic am. In daylight that view gener- will be good — but from dusk to n, vehicle operators rely on a d roadway lighting system for ty and an unobstructed, comfort- field of vision.

ighting energy costs are a large t of any roadway's operating ex- se, particularly in view of ever- easing energy rates. The chal- e, therefore, is to install a low- , relatively maintenance free ting system without sacrificing ty.

he Massachusetts Turnpike Au- rity turned to an efficient low ssure sodium (LPS) system for dway lighting, when it retrofitted watt mercury vapor lamps on the dian of the Weston-to-Boston ex- ion.

15-month field test of thirty-six watt lamps and luminaires — nted on existing poles on a half- stretch of the extension — con- ed the turnpike authority that the luminaires from North Amercian ips Lighting Corporation were the ient and energy-saving answer replacement.

f all commercial light sources, S costs the least to operate. For mple, based on a price of 9½ cents kwh, it costs $47.49 to operate one watt LPS lamp for the average 0 hours a year compared to .70 for one 400-watt mercury or lamp.

the first year of LPS operation on turnpike extension and at service s, kwh usage was reduced nearly ercent. Based on 9½ cents per , it costs $77,187 to operate the 5 LPS lamps for 4,000 hours a year us $287,137 for as many 400-watt cury vapor lamps. This repre- s an energy savings of $209,950. his rate, the $292,500 capital outlay he LPS lamps and luminaires will aid back in 1.39 years.

Characteristics

he lamp's monochromatic single w color improves visibility with er eye adaptation and visual clar- nd greater speed of perception of cts, both moving and stationary, ers instantly see them exactly as are without the eye adjusting to different color spectrums of other sources.

JOHN DIAS
Maintenance Engineer
Massachusetts Turnpike Authority, Boston, Massachusetts

At one foot-candle of road brightness, for example, the object will be perceived in 0.10 of a second in LPS light compared to 0.13 for high pressure sodium and 0.17 for mercury vapor.

The concentrated nature of low pressure sodium's spectrum keeps it from scattering when it hits fog, mist, rain, or snow, thus putting more light on the ground under difficult conditions. Another important feature is the light's low glare, which delivers greater visual comfort.

There is no fixture effect from extreme operating heat to shorten the lamp's life and no blink out due to vibration. The lamps are self-starting, with no need for an external igniter. Because they do not emit ultraviolet rays, LPS lamps do not attract insects. This keeps the luminaire lens clean, significantly reducing fixture maintenance costs.

Following the 15-month test experience, the initial contract for 700, 90-watt LPS lamps and luminaires to retrofit a ten-mile stretch of the extension from Weston to the Boston city limits went out for bids. All luminaires used on this project were supplied by North American Philips.

Lamp Details

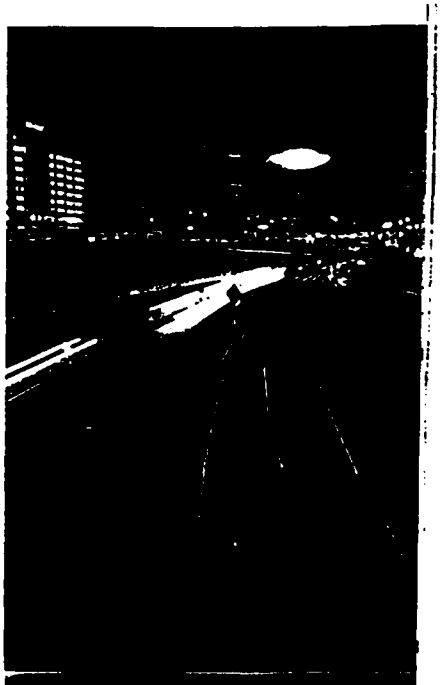
The constant lumen level and the energy savings afforded by LPS lamps and luminaires were the principal considerations in selecting these products. The LPS lamp chosen delivers a constant 13,500 lumens throughout it life, which is rated at 18,000 hours.

The 100 percent lumen maintenance of the lamp is provided by a special discharge tube made of non-staining glass with dimples to collect the sodium and prevent it from settling on the inner surface of the tube. The discharge tube is enclosed in a clear outer bulb.

The bulb has an internal indium oxide coating that allows visible light to pass through, but reflects most of the infrared radiation back to the discharge tube. Thus, the operating temperature of the lamp is maintained constant at about 260°C, resulting in an extremely high luminous efficacy approaching 200 lumens/watt.

The luminaire has a corrosion resistant die cast aluminum housing and an unbreakable prismatic polycarbonate lens, which is hinged and secured with spring latches for easy access to the lamp. It also contains a closed-cell neoprene rubber gasket for rainwater tightness and a slipfitter that will accommodate a 14-in. straight or tapered mounting arm.

In August 1984, a year after the initial installation on the Boston extension, Philips supplied 425 LPS lamps and luminaires for placement on the remaining five-mile section and six on and off ramps into Boston, and 500 LPS lamps and luminaires for installation on the acceleration and deceleration lanes at 14 turnpike restaurant service areas from Boston to the New York state border. □□□



■ LOW pressure sodium lamp lights the way for motorists on Boston end of the Massachusetts Turnpike Extension.

Appendix A-9 - Retrofit Ballast Kit Reduce Streetlight Conversion Costs

PG&E saved more than $1.4 million during the last year of the HPS conversion program by using retrofit ballast kits instead of replacing the entire fixture.

Retrofit Ballast Kits Reduce Streetlight Conversion Costs

SINCE most communities must rely on utility companies to power their streetlights, the 150-percent increase in the cost of purchased electricity over the last ten years has hit municipal budgets as hard as the consumer's pocketbook, making towns and cities particularly receptive to innovations that will cut their electrical costs.

So, in 1978, San Francisco based Pacific Gas & Electric Company (PG&E) undertook a massive conversion program to change more than 237,000 utility-owned street lights and dusk-to-dawn lights from mercury to high pressure sodium (HPS) lamps. During the first years of the program, conversion required complete replacement of each existing fixture with a new HPS luminaire. The price of the ballast retrofit kits available at that time plus the labor to install them made reconstructed luminaires more expensive than new ones. Nor were these early kits compatible with the cobra head streetlights most of PG&E's customers use.

In 1981, the utility evaluated several new ballast kits and found that the labor cost for installation was the same as the labor cost for replacing the entire fixture. Since the cost of the new kit was as much as 50 percent less than a new cobra head fixture, PG&E in 1982 switched from replacing the entire fixture to retrofitting.

The new ballast kit, supplied by Universal Manufacturing Corp, Paramus, New Jersey, consists of a small size, lightweight core and coil ballast for a 70-watt HPS lamp and an appropriate pre-wired starter, both already attached to twin mounting brackets to fit all PG&E's applications.

Rebate Program

From 1978 on, PG&E has been encouraging municipalities that own their streetlights to convert to HPS by pointing out the 15- to 30-percent savings on energy costs. When the ballast retrofit kits were developed, PG&E made conversion even more attractive by instituting an energy rebate program. To spur conversion, PG&E offered its municipal customers who service and maintain their own streetlights up to $72 for each streetlight converted and provided them with information on low-interest loans available from the California Energy Commission. For customers whose streetlights are serviced by the utility, PG&E agreed to absorb all costs and do the conversions, using the ballast retrofit kits wherever applicable, which was on nearly all the streetlights.

More than 34,000 municipally-owned streetlights were kit-converted during 1982 and 1983, and another 9,200 in the first six months of 1984. Today, 116,000 of the 186,000 municipally-owned fixtures have the HPS lamps, and the conversion and rebate programs are still underway.

PG&E undertook the conversion programs for several reasons. Switching to HPS lamps permitted the utility to reduce the connected kilowatt load of the street lighting system by more than 4,000 kilowatts and save more than 250 million kwh. Customers participating in the rebate program have saved over $3 million in the last two years.

For example, the town of Freemont, which owns 6,950 streetlights, was one of the first communities to participate in the program and received over $500,000 from PG&E to convert its lighting. Based on current rate schedules, the switch will enable the town to save more than $18,000 a month. On a smaller scale, Chico, California, owns 59 streetlights and will soon receive $4,238 for conversions. The monthly savings in this case will only amount to $258, but it represents a 41-percent decrease in Chico's costs.

Besides benefiting their customers, the program also helps the utility. The energy savings will enable PG&E to extend service to new customers without building new power generation facilities.

Early Payback

When the rebate program began in 1983, customer municipalities that service their own streetlights converted 17,000 units to HPS and found that the energy savings allowed payback of conversion expenses within one year.

The utility reports that many of the communities that maintain their own streetlights went ahead with conversions because the ballast retrofit kits have allowed them to control labor costs. The kits are easily learned and used in the field, so that a community can use its own staff, thereby eliminating the need for an outside contractor.

Moreover, using kits eliminates the need to remove and dispose of any fixtures. And, more streetlights can be converted in a day by retrofitting because municipal trucks can carry dozens of kits but only a few replacement fixtures.

The switch to HPS had been preceded by an earlier conversion program. Back in the mid 1960s PG&E achieved significant labor and energy savings by converting more than 123,000 incandescent streetlights to mercury

APPENDIX B

An Analysis of:

Why is Street Lighting a Benefit to Gainesville

Benefit/Cost Analysis to New Roadway Lighting System

Basic Model

Anticipated costs and benefits of lighting one mile of unlit roadway in Gainesville based on Annual Worth analysis.

Benefits	Costs
Reduced Accidents	Installation
~~Crime Reduction~~[29]	Maintenance
	Operation
	Increases in Pole

Accidents

When the Benefit to Costs ratio is greater than one the project is presumed to be feasible. Furthermore, higher ratio's among different parameters yields the most beneficial and optimum parameters. Assume use of Cut-off luminaire in all cases with the following typical characteristics:

Overall Benefit/Cost Ratio = 6.25

Inputs		Description	
50000	*	Average Daily Traffic(ADT-Existing or Projected)	
2	*	Night Accident Rate per Million Miles (NRU)	
10.00%	*	Cost of Money(i)	
200	*	Pole Spacing in Feet	
10	*	Pole Off-Set fm Traffic Edge(Less than 5 to 30)	
150	*	Watts per Luminaire	
1	*	Pole type(1 - wood, 2 - concrete)	
30	*	Pole Mounting Height (25/30/35),	Pole = $ 293.80
1	*	Luminaires per pole	
4	*	Accident Reduction Factor #(ARF)	1 - Urban Freeway - Interchange 2 - Urban Freeway - Mainline 3 - Urban Intersection 4 - Urban Mainline - Commercial 5 - Urban Mainline- 25% Commercial 6 - Urban Mainline - 5% Commercial
40.00%		Accident Reduction Factor (ARF)	
0.59		Expected Number of Pole Accidents per Year	
15		Pole Life in Years	

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[29] Based on the 1979 National Evaluation Program Report of Street Lighting Projects for the U.S. Department of Justice, the following is concluded; "Although there is no statistically significant evidence that street lighting impacts the level of crime, especially if crime displacement is taken into account, there is a strong indication that increased lighting--perhaps lighting uniformity--decreases the fear of crime."

$676.80 Total Installation(Luminaire($383.00) & pole)
$32.20 Annualized Operation & Maintenance Cost(AMC)
30.00% Percentage of ADT at Night (%ADTn)
$28,850 Average Accident Cost (AAC)

Description

Benefits - Reduced Accidents
==========

Benefits: (1) Reduction in number & cost of vehicle accidents per year

Benefit = ADT x %ADTn x 365 x NRU/1x10^6 x ARF x AAC

*Equation From Roadway Justification Program - FDOT

DATA & UNITS:

ADT = 50,000 Vehicles/day * 365 Days/year
%ADTn = 30% of Normal Traffic Flow Expected at Night(FDOT)
NRU = 2 Night Accidents attributable to no street lighting per million miles.
ARF = 40% Accident Reduction Attributable to Mainline Commercial over other state wide conditions(FDOT).
AAC = $28,850 savings per accident averted in Florida based on conclusions of a 30 January, 1988 study by safety office of FDOT.

Benefit = $126,363

Costs - Erection Costs
==========

Costs: (1) Annual Maintenance & Operation Costs
(2) Annual Worth of Installation Costs
(3) Increase in Annual Accidents Caused from poles

Costs =(AMC/mile + Annual Installation Costs (AIC)/mile + Annual Accidents caused by poles(AAP))

DATA & UNITS -

AMC = $32.20 Annual Maintenance Cost attributable to each luminaire based on Type 14 light O & M Charges GRU per pole - Light

AIC = $676.80 Installation Costs(A/W,i,n) luminaire based on GRU Pole(wood) & Type(#14) charges.

AAP = .59 accidents caused by poles based on a 10' setback at 150' spacing based on table 19 of the 1978 Roadway Lighting Handbook.

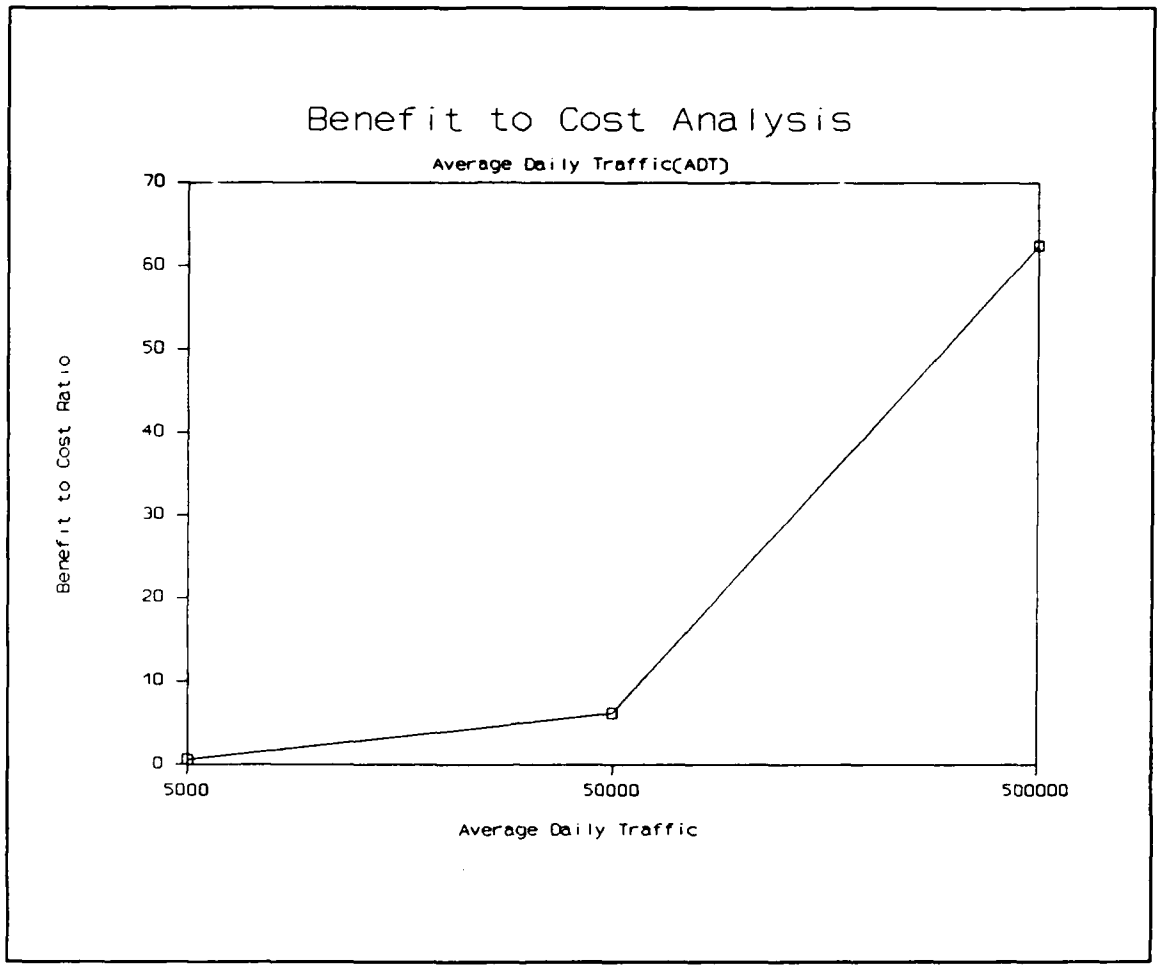
AIC =	$88.98
AMC =	$32.20
Poles/mile =(5280'/space)	26
Luminaires/pole =	1

AIC/mile =	$2,349
AMC/mile =	$850
AAP/mile =	$17,022
Costs =	**$20,221**

Analysis of Model's Sensitivities

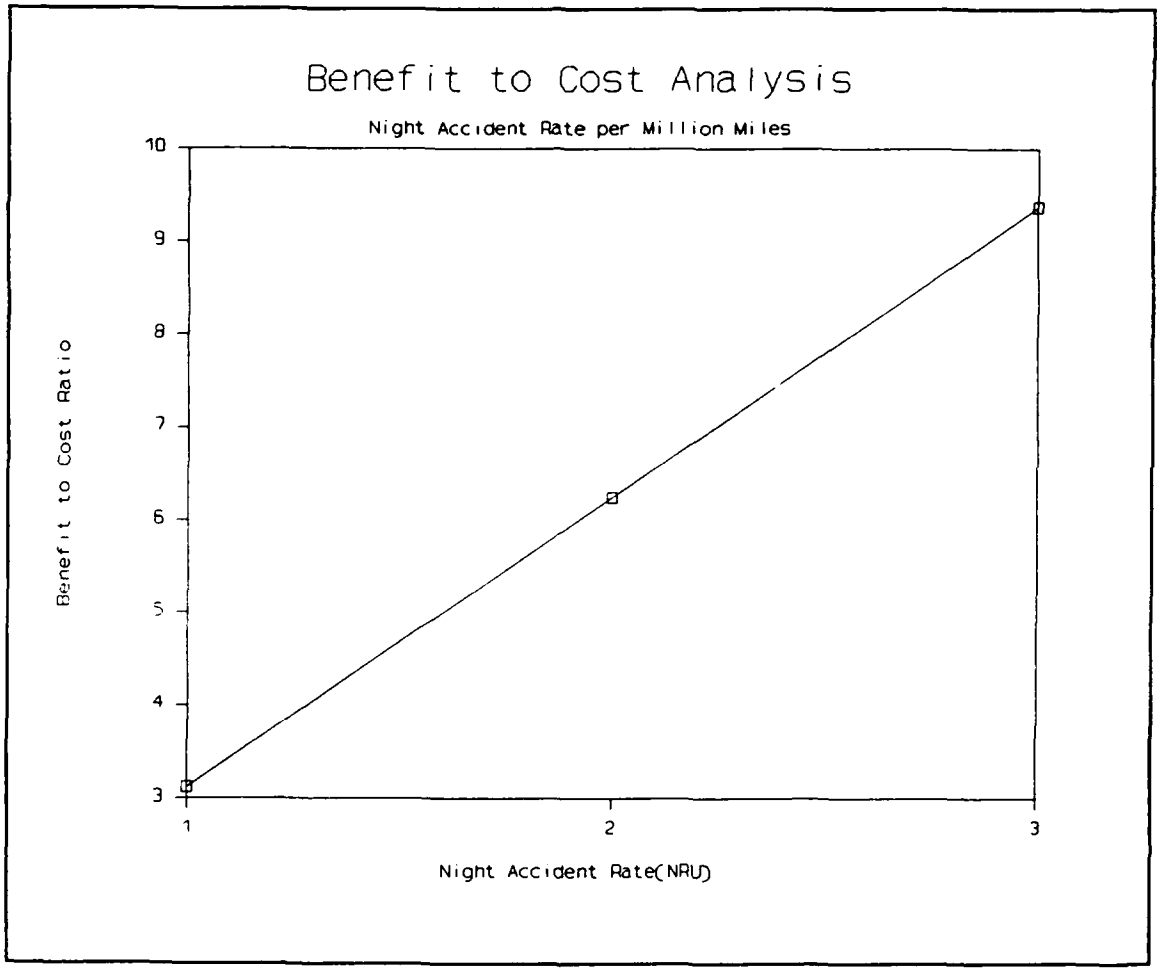
By altering each of the basic model's typical inputs while holding all other inputs constant reveals how sensitive each input is to the overall benefit to cost ratio of street lighting for Gainesville. This will prove useful in ascertaining the most important criteria in the design of lighting, thereby allowing management to concentrate it's efforts to those areas of most benefit. This would be especially important in determining where limited resources should be allocated for maximum benefits in a street lighting plan for Gainesville. Also certain sensitivities may reveal the best design considerations to street lighting in this City. The ten models influence to the Benefit to Cost Ratio is each tabulated and graphically presented based on the following parameters:

1. Average Daily Traffic Flow
2. Night Accident Rate per Million Miles
3. Pole Type
4. Pole Mounting Height
5. Luminaires per pole
6. Accident reduction Factor
7. Cost of Money
8. Pole Spacing
9. Pole off-Set from Traffic Edge
10. Watts per Luminaire



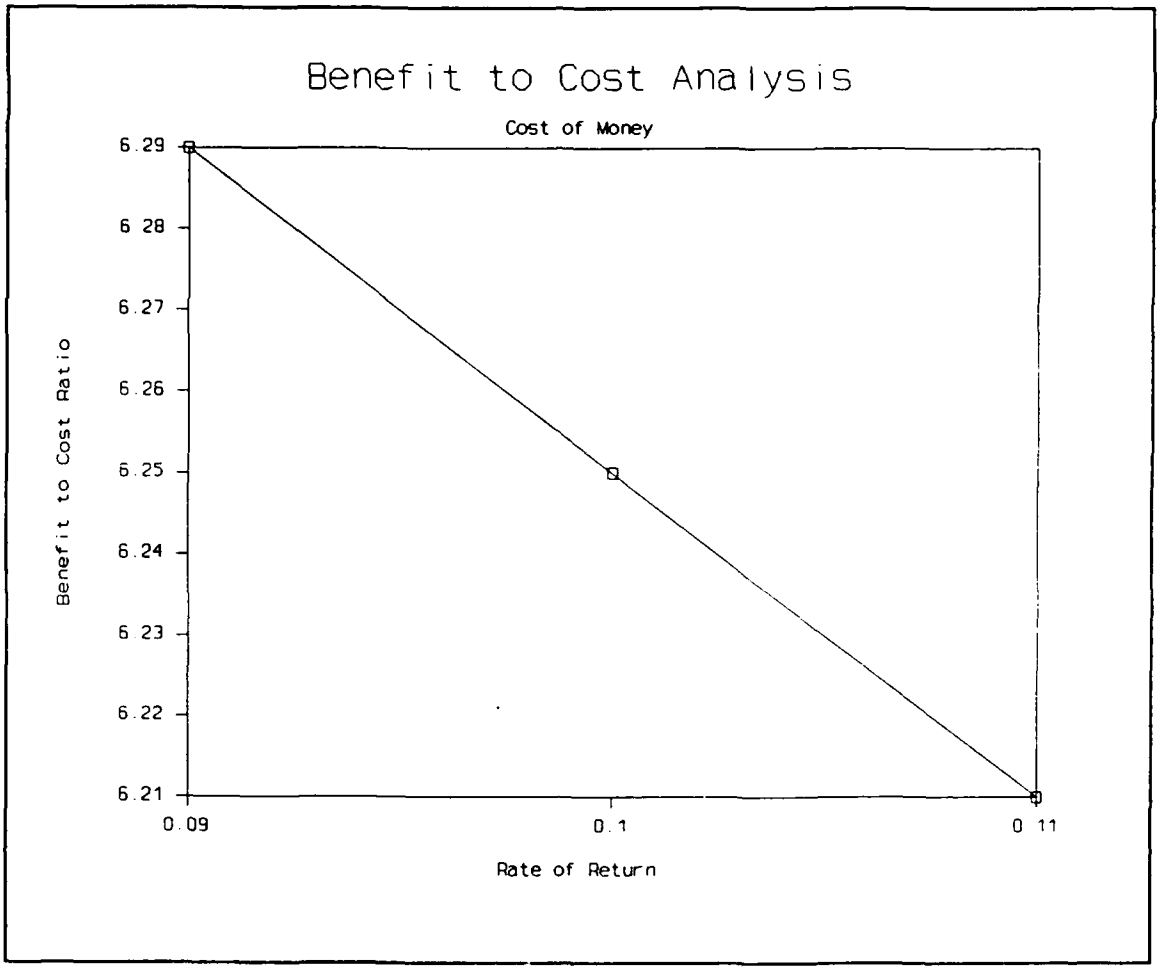
Analysis

As the average daily traffic(ADT) is increased the B-C Ratio responds linearly. A tenfold increase in ADT produced a tenfold increase in the B-C Ratio if lighting is considered. The Break Even flow rate for the Basic Model would occur at 8065 Vehicles per Day.



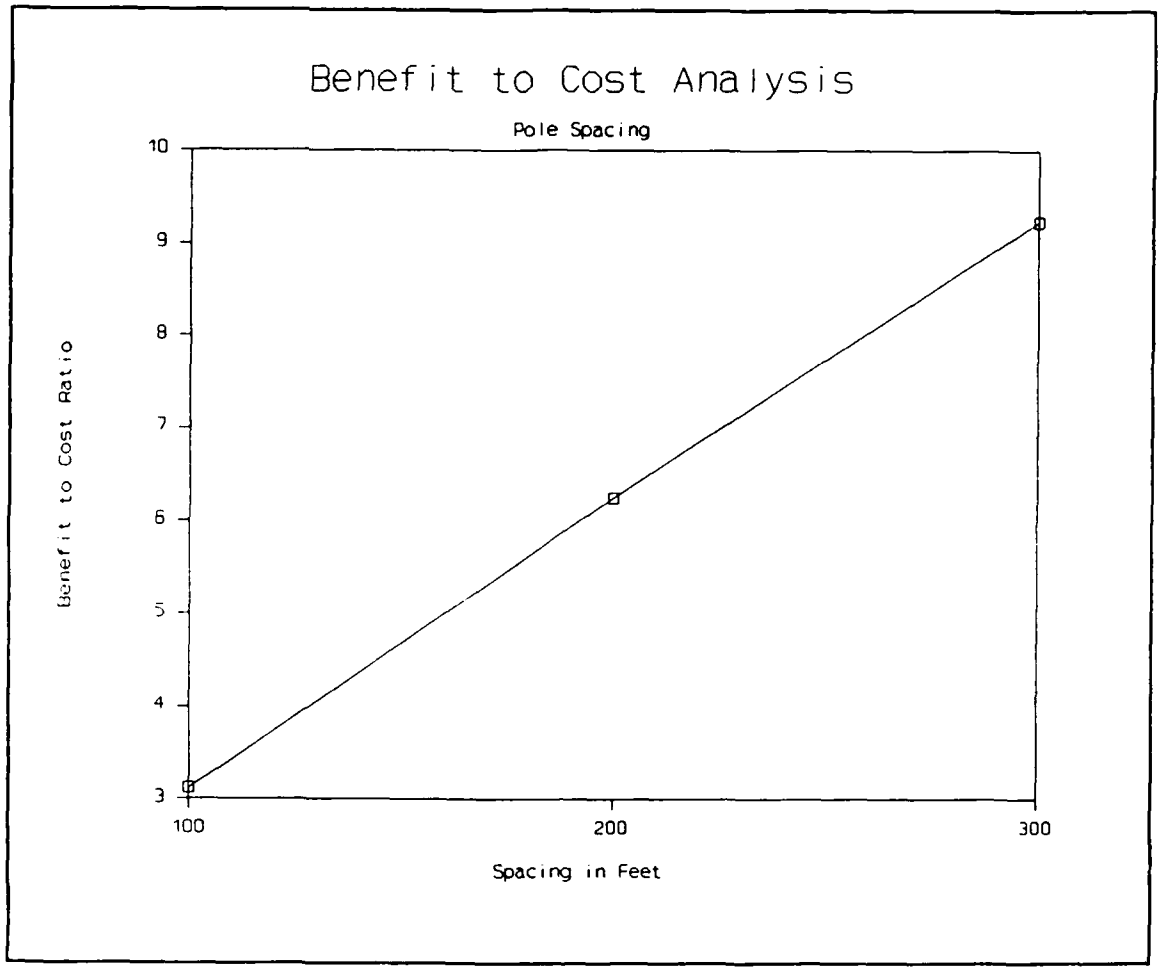
Analysis

As the Night Accident Rate(NRU) per million miles is increased incrementally the Benefit-to-Cost(B-C) Ratio responds linearly. Tripling the NRU of one to three per million tripled the B-C to almost ten. The Break Even NRU for the Basic Model occurs at .32 Accidents per million miles. Since the Florida Department of Transportation assumes 2 to 3 NRU's when data is not available, a break even this low can be discounted unless confirmed.



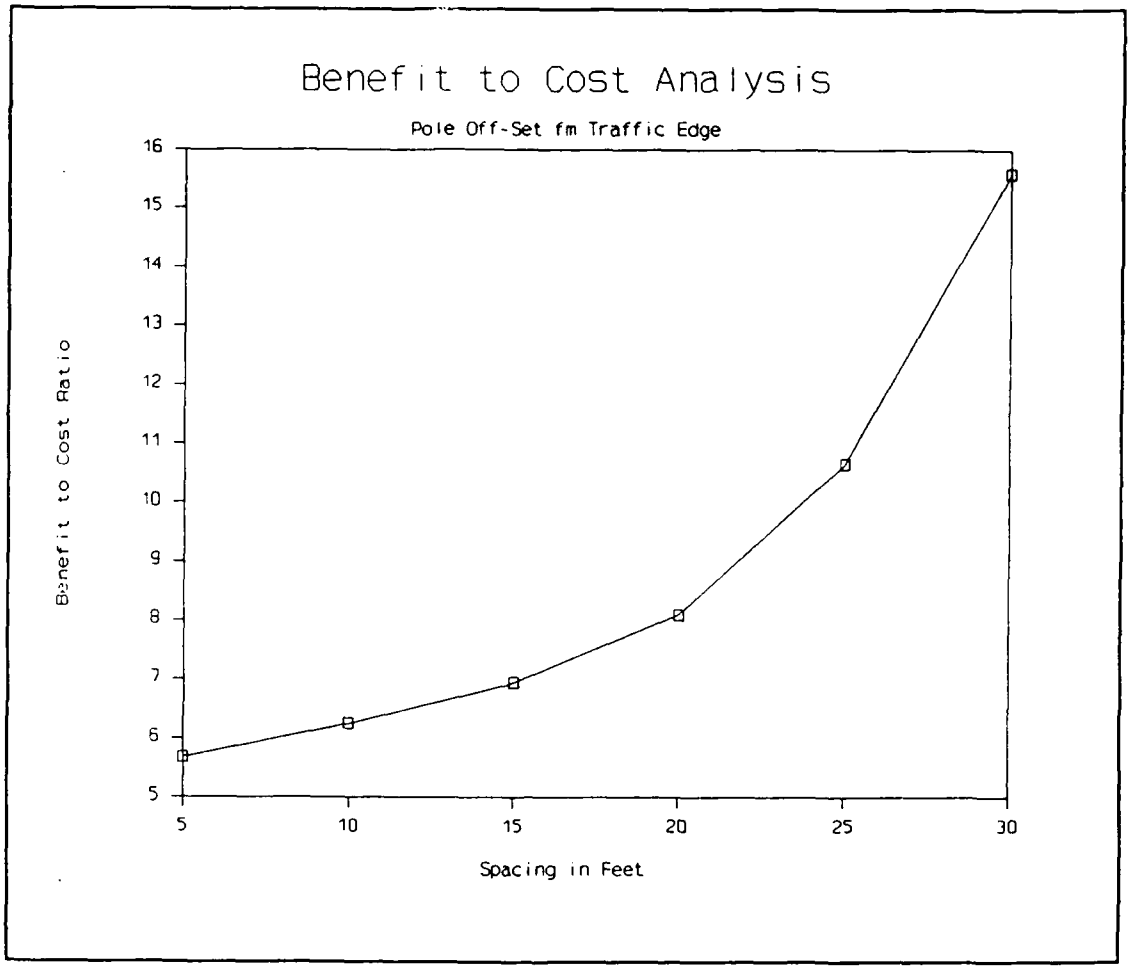
Analysis

As the Cost of Money is increased incrementally B-C Ratio decreased constantly between 9 and 11 percent. As the cost of money increased by ten percent, the B-C Ratio decreased by a constant .04 over this estimated range. The break even point for the Basic Model occurs at an unrealistically high interest charge and is therefore inherently discounted. Therefore, the cost of money has little impact on the overall Benefit to Cost Ratio.



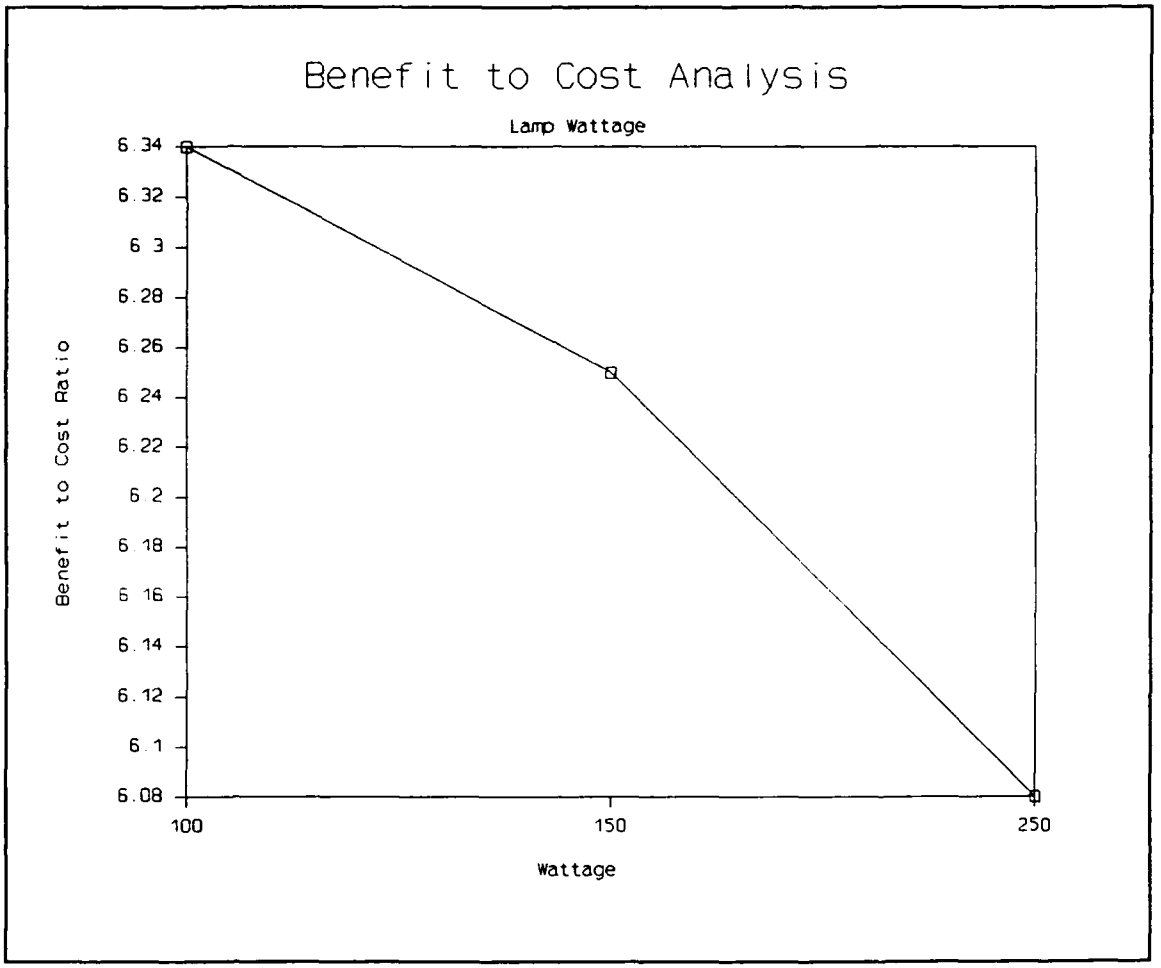
Analysis

As the Spaces between the poles is increased incrementally, the B-C Ratio increases linearly. As the pole spaces are tripled from one to three hundred feet, the B-C Ratio tripled from three to over nine. The break even point for the Basic Model occurs at a pole spacing of 32 feet.



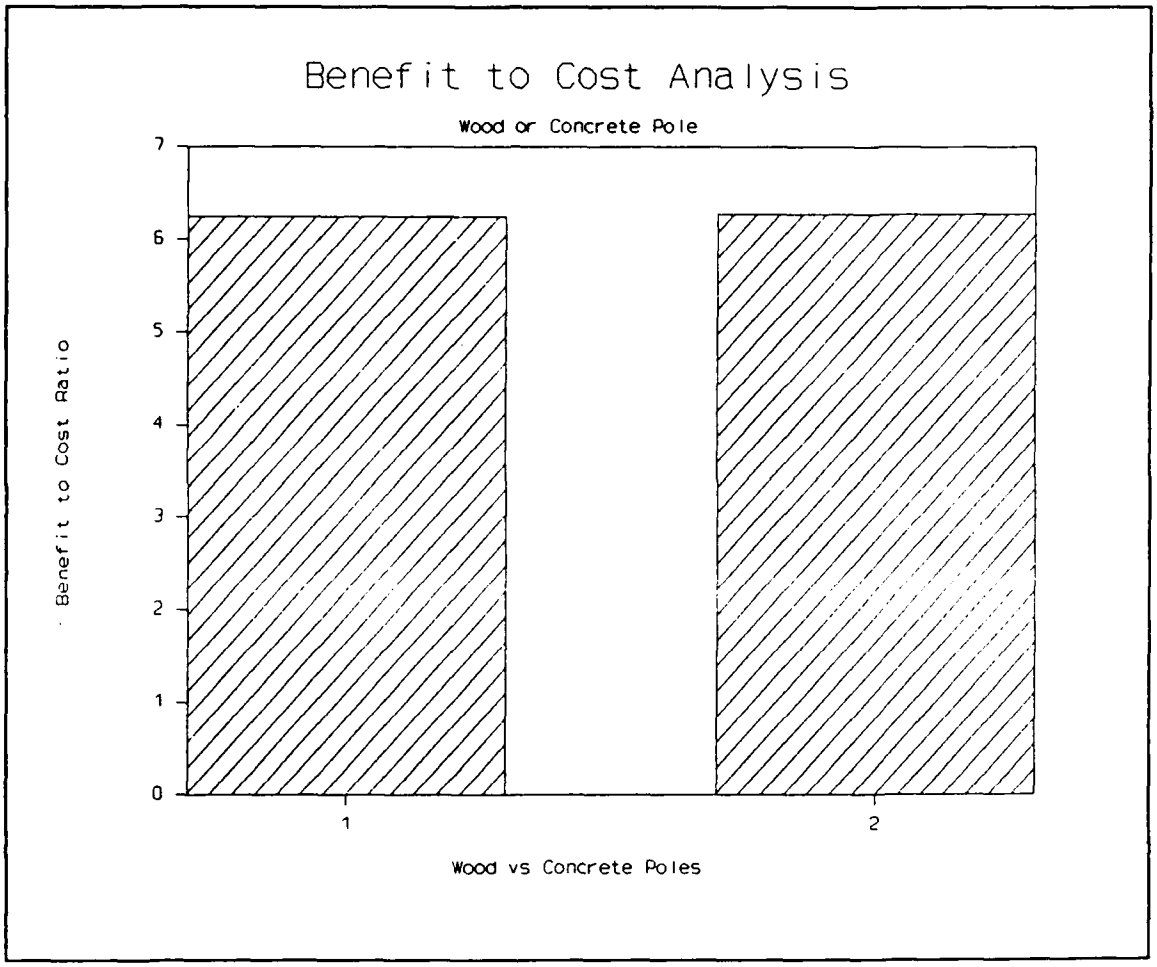
Analysis

As the off-set is increased at five foot increments, the B-C Ratio increased less than linearly. More importantly from the graph, off-setting in excess of 15 feet has more benefit than lesser off-sets. It can be seen from the data that 30 feet off-sets coupled with 350' spacings produce extremely low expected numbers of accidents attributable to pole impacts. Therefore, increasing these values would have a marginal effect outside this range.



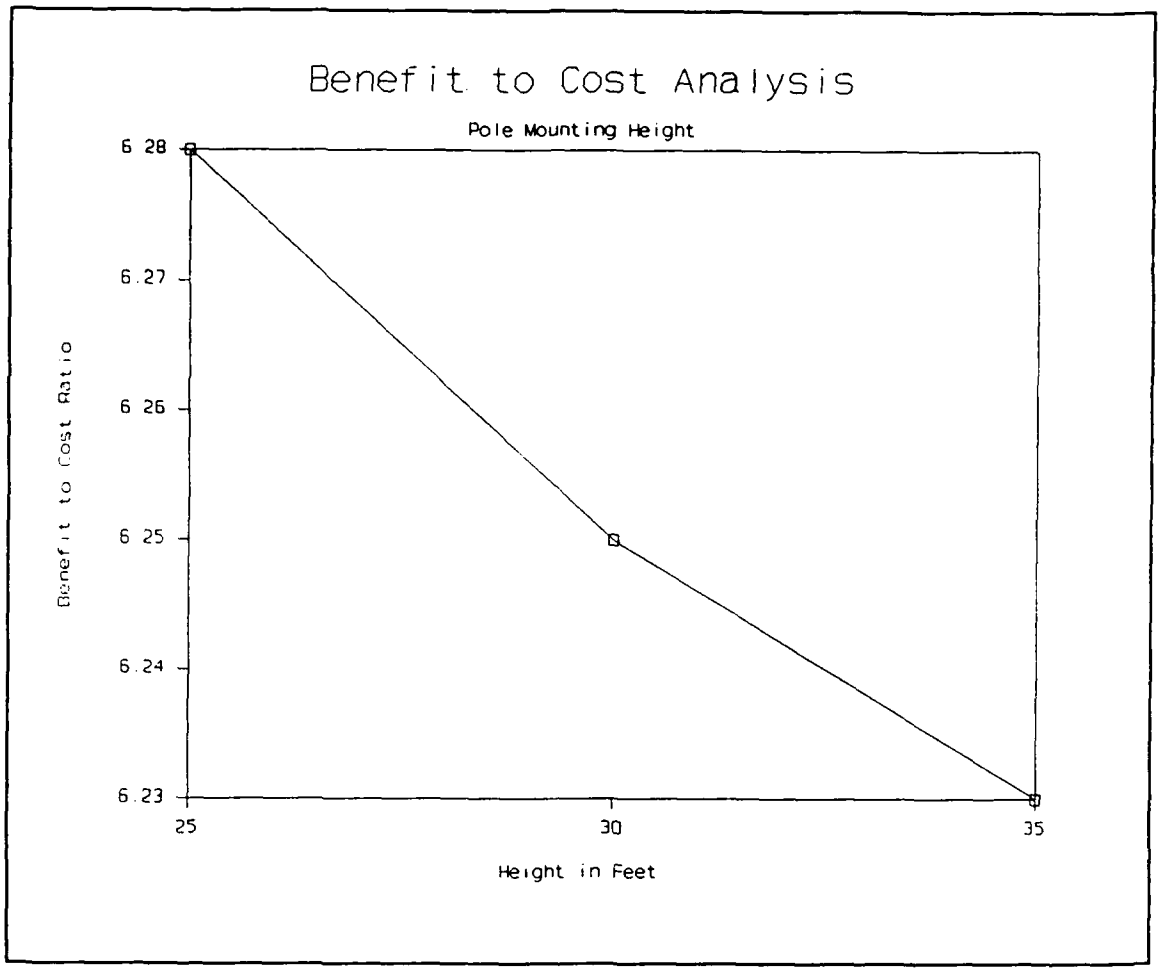
Analysis

As the lamp wattage is increased, the B-C Ratio decreases linearly. As the lamp wattage increased by 50 watts from 100 to 150 watts, the ratio decreased by .09. Similarly as the lamp wattage was increased from 150 to 250 watts, the benefit to cost ratio decreased by .17. Increasing lamp wattage marginally decreases the benefits of the system.



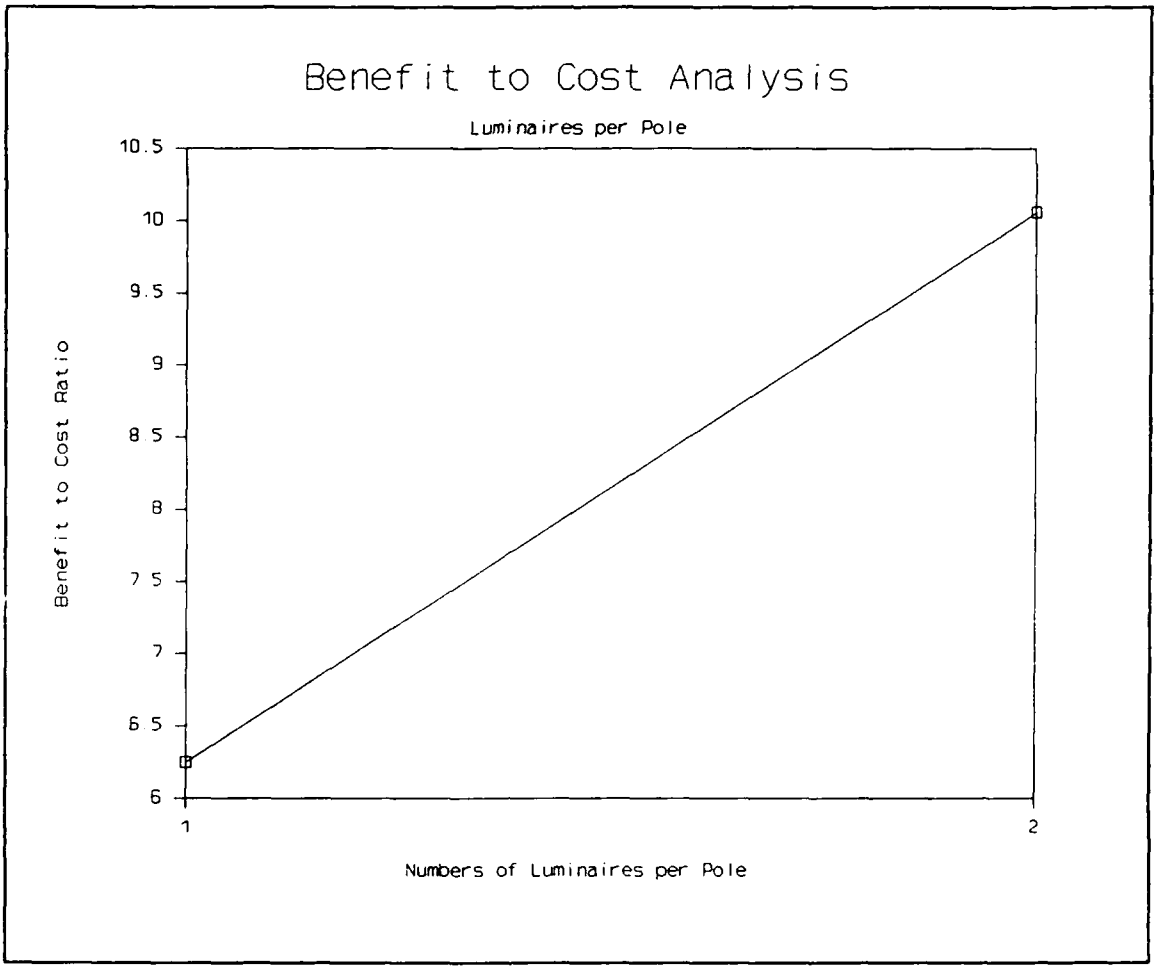
Analysis

As can be readily seen, the benefit of using a concrete over a wood pole is negligible. The wood pole is .03 less than the concrete pole of 6.28. One must keep in mind, this analysis in no way recognizes a life cycle comparison between the two choices. Instead, both choices are compared on their effect to the overall benefit to the system.



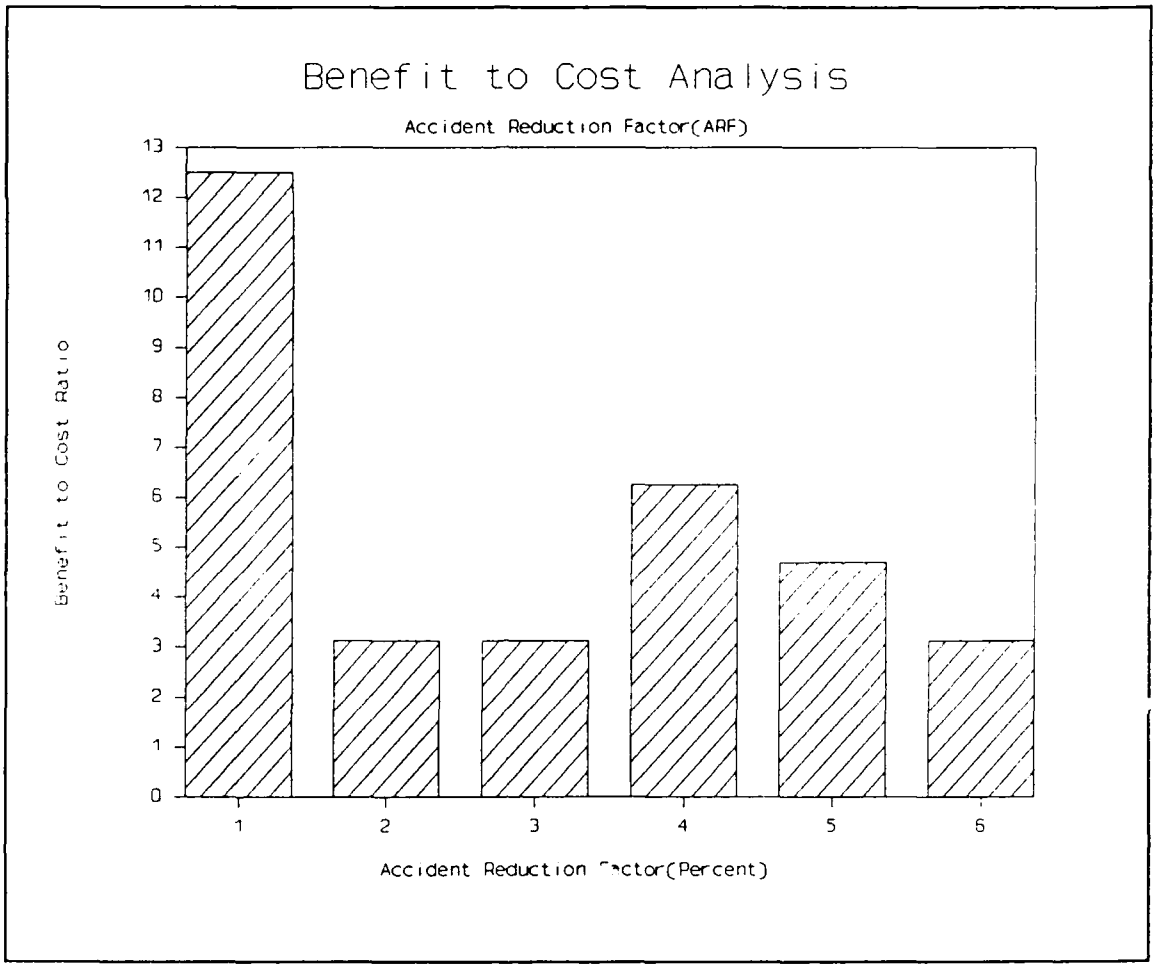
Analysis

From the range of poles inputed(25, 30 & 35 ft), increasing the pole height decreases the benefit to cost ratio marginally. The largest decrease of .03 occurs when a 30 foot pole is chosen over a 25 foot pole. A .02 decrease in the ratio occurs when the choice is from a 30 foot pole to a 35 foot pole.



Analysis

Increasing the luminaires per pole linearly increases the benefit to cost ratio. Putting 2 luminaires on each pole increases the benefit from 6.25 to 10.06.



Analysis

According to the following schedule, the ratio shows the best benefits for street lighting occurs at rural intersections.

Accident Reduction Factors FDOT		B-C
Rural Intersection	1	12.50
Rural Mainline	2	3.12
Urban Intersection	3	3.12
Urban Mainline - Commercial	4	6.25
Urban Mainline - 25% Commercial	5	4.69
Urban Mainline - 5% Commercial	6	3.12

Also of note is the doubling of ambient benefits attributable to lighting streets in urban mainline - commercial areas.

Conclusions

Examination of the analysis of each of the sensitivities in relation to each other uncovers clear indicators for an efficient approach to street light planning and design in Gainesville. Of the ten parameters investigated, three have tremendous importance in realizing the most benefit of street light planning in the City: Average Daily Traffic Flows, Accident Reduction Factors attributable to Department of Transportation hazard areas, and Night Accident Rates per million miles. To a lesser extent, street light design is encouraged by findings in maximum allowable pole spacing, off-sets, lamp wattages, luminaires per pole and mounting heights. Little or marginal benefits can be attained in choosing pole types or anticipating interest rates. Based on these findings, allocating time to sensitive areas while slighting others will realize optimum street lighting organization and execution.

The benefits of street lighting increases as the flow of traffic increases. After merely 8000 vehicles per day, benefits are realized in lighting Gainesville's streets. Based on Department of Transportation Accident Reduction Factors, rural intersections and urban mainlines with commercial activities show the most improvement in reducing accidents when street lighting is added. Finally, night accident rates greater than .32 per million miles unlit

demand higher benefits with street lighting. Based on these findings, city lighting planners should concentrate their warranting or efforts on high flowing arterials in commercial areas with the highest recorded city-wide accident rates.

Both pole off-set and pole spacing realized increasing benefits as distances of the poles increased away from the traffic edge as well as away from each consecutive pole. This was supported by increased benefits in situations where fewer poles were used as more luminaires were placed on each pole from one to two.[30] Although **slightly** reducing overall benefits to costs of the system, increasing both lamp wattages and mounting heights encourages higher pole spacings in the design process and would therefore tend to improve the overall benefits to the system. Finally street light designers should, within design requirements, encourage higher pole spacings and greater off-sets by encouraging higher lamp wattages and mounting heights when not restricted.

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[30] Placing two luminaires on one pole often requires pole placement on a median. Although this is encouraged by the Lighting Handbook, this could directly restrict another favorable factor in reducing pole off-set from the edge of the traffic. Therefore increasing luminaires per pole should coincide with measures to protect motorists from the poles.

Synopsis of Tables Used in Data Formulation

Pole Charges - GRU's Pole Charges Schedule

Mounting Height	Wood	Concrete
25	$264.91	$407.89
30	$293.80	$422.84
35	$312.82	$555.83

Pole Life - Pole Lives based on FDOT Estimate

Type		
1	15	Wood
2	30	Concrete

Lighting Type(cut-off)- GRU's Public Street Lighting Cost

Type	Wattage	Installed	Annual O & M
11	100	$377.32	$21.42
14	150	$383.00	$32.20
16	250	$417.19	$48.61

Accident Reduction Factors - FDOT

Rural Intersection	1	80.00%
Rural Mainline	2	20.00%
*Urban Intersection	3	20.00%
*Urban Mainline - Commercial	4	40.00%
*Urban Mainline - 25% Commercial	5	30.00%
*Urban Mainline - 5% Commercial	6	20.00%

* Preliminary Non-Controlled Access Roadway Data from FDOT Lighting Justification Program

Expected Number of Lighting Pole Accidents Per Mile *

	Feet Off-Set					
Spacing	0	10	15	20	25	30
100	1.31	1.18	1.03	0.83	0.59	0.33
150	0.88	0.79	0.70	0.57	0.40	0.22
200	0.66	0.59	0.52	0.43	0.30	0.17
250	0.53	0.48	0.42	0.34	0.24	0.13
300	0.44	0.40	0.35	0.29	0.20	0.11
350	0.38	0.34	0.30	0.25	0.17	0.10

*Accidents per mile per year. Roadway Lighting Handbook 78'

Data Developed from varying inputs to Basic Model

Average Daily Traffic ((ADT)-Existing or Projected) vs B-C

5000	0.62
50000	6.25
500000	62.49

Night Accident Rate per Million Miles (NRU) vs B-C

1	3.12
2	6.25
3	9.37

Pole type(1 - wood, 2 - concrete) vs B-C

1	6.25
2	6.28

Pole Mounting Height (25/30/35) vs B-C

25	6.28
30	6.25
35	6.23

Luminaires per pole vs B-C

1	6.25
2	10.06

Accident Reduction Factor (ARF) vs B-C

Rural Intersection	1	12.50
Rural Mainline	2	3.12
Urban Intersection	3	3.12
Urban Mainline - Commercial	4	6.25
Urban Mainline - 25% Commercial	5	4.69
Urban Mainline - 5% Commercial	6	3.12

Cost of Money vs B-C

0.09	6.29
0.1	6.25
0.11	6.21

Pole Spacing in Feet vs B-C

100	3.12
200	6.25
300	9.24

Pole Off-Set fm Traffic(Less than 5/10/15/20/25/30) vs B-C

5	5.68
10	6.25
15	6.94
20	8.1
25	10.66
30	15.59

Watts per Luminaire vs B-C

100	6.34
150	6.25
250	6.08

APPENDIX C
INTERVIEWS

Friday, 13 January - (.25 Hours)
Phoncon w/ Electrical Engineering Tech 2(EET2) David Lea, GRU
Physical Lighting Criteria for 39th Ave

Friday, 20 January - (.5 Hours)
Phoncon w/ Mr Bob Burgdall, GRU
Street Lighting Rate

Friday, 3 February - (2.5 Hours)
Mtg w/ EET2 David Lea, GRU
Physical Lighting Criteria
Roadway Lighting Report

Friday, 17 February - (.75 Hours)
Mtg w/ Mr Andre Davis, City Management Analyst
Energy Element
Progress Update

Friday, 3 March - (.25 Hours)
Briefed Professor Collier
Illumination Standards - Signs
Progress Update & Questions

- (.5 Hours)
Mtg w/ Mr Brian Canely, Dir of Traffic Operations for City
Funding, Management and Goals

Monday, 6 March - (.25 Hours)
Briefed Professor Collier
Progress Update & Questions

Friday, 17 March - (1.5 Hours)
Mtg w/ Ms Judy Fraser, City Clerk's Office
Funding & Objectives research fm Proposed Financial and Operating Plans
Lighting Task Force
Roadway Lighting Report

Monday, 20 March - (1.5 Hours)
Transportation to/from Lake City FDOT

- (.75 Hours)
Mtg w/ Mr Pierce, Director FDOT Lake City
Street Lighting Goals, Objectives and Management

- (.75 Hours)
Mtg w/ Mr Billy Dees, Utilities FDOT Lake City
Utility Reviews of Proposed Street Lighting Projects

- (1 Hour)
Mtg w/ Mr Hodges, Safety FDOT Lake City
Safety criteria in Roadway Lighting
The Informal Roadway Lighting Guide
Lighting Justification Software Package

Tuesday, 21 March - (2 Hours)
Mtg w/ Mr Bob Davis, GRU's Energy Advisory Committee(EAC) Representative
EAC's Charter, Duties & Goals
Energy Element
Roadway Lighting Report
Street Lighting Rates
Lighting Task Force

- (.75 Hours)
Mtg w/ EET2 David Lea, GRU
Lighting Task Force
Roadway Lighting Report

- (2.5 Hours)
Attended full EAC Monthly Meeting for March
SOME TOPICS OF MEETING RELEVANT TO REPORT:
Energy Element
Energy Emergency Plan

Tuesday, 9 May - (5 Hours)
Transportation to/from Tallahassee FDOT

- (1.0 Hour)
Mtg w/ Mr Clark Scott PE, Engineer of Traffic Plans
Potential Management Objectives for a Lighting Plan
Safety criteria in Roadway Lighting
Lighting Justification Software Package
Physical Lighting Criteria
Street Lighting Rate

- (.5 Hours)
Mr Bodiford CE2, Lighting Technician
Lighting Justification Software Package
Physical Lighting Criteria

Tuesday, 24 May - (2 hours)
Mtg w/ EET2 David Lea, GRU
Lighting Justification Software Package
Various findings and questions raised in the Report

- (.5 hours)
Mtg w/ Professor Collier
Submitted Report for Review and input

Friday, 2 June - (.75 hours)
Phoncon w/ Mr Lester Jones, FDOT Tallahassee
Potential Management Objectives for a Lighting Plan
Safety criteria in Roadway Lighting
Street Lighting Rate
Lighting Justification Software Package
Physical Lighting Criteria

Friday, 9 June - (1 hour)
Mtg w/ EET2 David Lea, GRU
Lighting Contractors
Organizational Diagram
Light Assembly
City Billing
HPS to MV
Crime vs areas Lighted
Rental Lighting

- (.5 hours)
Mtg w/ Professor Collier
Reviewed Report Progress
w/ further recommended study areas offered

Wednesday, 14 June - (1 hour)
Mtg w/ Mr Tom Bird, City Budget Office
Review of Street Lighting Budget/Expenses

- (.5 hours)
Phoncon w/ Mr Walt Qualmann, ILLUME Inc.
Physical Lighting Criteria
Roadway Conversion Lighting Report

Tuesday, 20 June - (1 hour)
Mtg w/ Mr Mike Roads, Designer - Ingley, Campbell & Moses
Lighting Liability
Standards and Methods Used in Lighting Design
Lighting Suppliers

Thursday, 22 June - (1.5 hours)
Mtg w/ Mr Jerry Donaldson, GRU -
ILLUME Progress 81-85
Organizational Diagram
Design areas - Liability Question
Lighting Criteria - Cut-offs
Light Maintenance Program - Field Surveys
Rental Lighting

Tuesday, 27 June - (.5 hours)
Mtg w/ Capt Mitchel, Gainesville Police - Crime Analysis
Crime Rate changes in street lighting projects
SE 15th(8th Ave to City Limits)
Police Lighting Interests

Tuesday, 27 June - (1 hour)
Mtg w/ Mr Cameron, GRU Electric System Operations Asst Manager
Managed/Liability
Lighting in Ordinances
Lighting Criteria and standards - Cut-offs
Light Maintenance Program - Field Surveys
Flow Diagram

Thursday, 29 June - (1 hour)
Mtg w/ Mr Beaulieu, GRU Electric Engineering Manager
Lighting Work
Lighting Criteria and standards - Cut-offs
Street Lighting improvements in the future
Lighting Equipment
City Traffic Department Billings for Street Lighting
Cost of Lighting Capital

APPENDIX D
REFERENCES

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City of Gainesville, Gainesville Energy Element - 1988 Progress Report, Inter-Office Communication, Gainesville, 14 February 1989.

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"Economical Approach to Light Pole Installation." Public Works, March 1987, p. 78.

Florida Department of Transportation, Design Criteria For Highway Lighting - Directive No 0747-56, April 1978.

Florida Department of Transportation, Highway Lighting Plans - Guidelines, 1988.

Florida Department of Transportation and the University of Florida Transportation Research Center, Justification of Roadway Lighting Systems (including Basic Computer Program).

Gainesville Energy Advisory Committee(EAC), Agenda, 21 March, 1989.

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Gainesville Regional Utilities, Public Street Lighting Rates, March 1989.

ILLUME, Roadway Lighting Conversion Report for the City of Gainesville, Florida, Portland, Oregon, 15 October, 1981.

"Informed Public Supports Street lighting Modernization." Public Works, September 1985, p. 114.

National Institute of Law Enforcement and Criminal Justice, National Evaluation Program: Street Lighting Projects, U.S. Department of Justice, Washington, D.C., January 1979.

"New Roadway Lighting Cuts Power Use." Public Works, December 1985, p. 43.

"Retrofit Ballast Kits Reduce Streetlight Conversion Costs." Public Works, March 1985, p. 87.

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UPACE: Utility Pole Accident Countermeasure Evaluation - SUMMARY, McTrans - Traffic Engineering Software, University of Florida, Gainesville, Florida.

U.S. Department of Transportation - Federal Highway Administration, Roadway Lighting Handbook, U.S. Government Printing Office, Washington, D.C., December 1978.